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# SURGERY

## GYNECOLOGY AND OBSTETRICS

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### THE RELATIONSHIP OF THE CONCENTRATION OF ASCORBIC ACID OF THE BLOOD TO THE TENSILE STRENGTH OF WOUNDS IN ANIMALS

JOHN B. HARTZELL, M.D., F.A.C.S., and WILLIAM E. STONE, Ph.D.,  
Detroit, Michigan

THE healing of wounds is a complex phenomenon and cannot be described in terms of a few specific governing factors. The regulation and control of growth of tissue presents problems not understood, and since the healing of wounds is dependent on the growth of tissue the problem of healing is not easy. However, there is certain information available regarding deterrents to healing in surgical wounds in patients. Detering factors may be classified as (1) general or (2) local. These have been discussed in recent reviews (5, 6, 10, 15).

From the Department of Surgery, Wayne University College of Medicine. This work was supported by grants from Frederick Stearns & Company and T. D. Buhl.

Read before the Forum on Fundamental Surgical Problems at the Clinical Congress of the American College of Surgeons, Boston, November 5, 1941.

In order that a wound may heal it must be at sufficient rest for the parts to adhere, but many mechanical factors found in surgical patients cause motion of the approximating edges. Imperfect suturing, activity on the part of the patient, coughing, straining, or rough handling on the part of attendants disturb the quiet of the wound. Locally, excessive trauma, infection, strangulation of tissue, presence of foreign bodies, and excessive tension, are factors which predispose to poor wound healing. These have been mentioned in most discussions of the subject, that they may cause difficulty in wound healing is obvious. Other factors, especially in clean and otherwise uncomplicated cases, are usually less apparent and must be considered as due to general disturbances in the patient, since

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no local or mechanical cause is known. Con- current disease and malnutrition probably are the most important of the general causes of poor wound healing. These have until recent years received little attention.

Experimental data have shown that vitamin C deficiency plays an important part in wound healing in the experimental animal. Aschoff and Koch in 1919 stated that in scurvy the main primary deficiency is a lack of intracellular cement substance. Hoyer in 1924 verified these observations in the scorbutic guinea pig and noted changes which were due to a lack of collagen. Wolbach and Howes demonstrated that the histological basis for the failure of wounds to heal in the presence of vitamin C deficiency lies in the inability of the supporting tissues to produce and maintain intracellular substance and later Menkin, Wolbach and Menkin found that microscopic sections of tissues of scorbutic animals demonstrated the deposition of increasing amounts of intracellular cement substance depending on the amount of vitamin C administered. Taffel and Harvey reported that the tensile strength in stomach wounds of the partially scorbutic guinea pig is much decreased from the 8th to the 10th day. Lanman and Ingalls have shown that guinea pigs maintained on approximately one-fifth of the minimal protective dose of ascorbic acid exhibited healing of operative wounds inferior to those of normal controls. Von Jeney and Torb were able to demonstrate in *in vitro* cultures of fibroblasts a sudden increase in collagen fibrils when ascorbic acid was added to the medium. Wolbach (23) states that deficiencies of vitamin C result in abnormalities of all intracellular substances having collagen as their basis, and that its absence prevents the formation of the matrices of white fibrous tissue, bone, cartilage and dentin. He states further that in vitamin C deficiency the pathological picture is produced by resorption of intracellular materials in both growth and reparative reactions. In such instances, if vitamin C is supplied either in natural foods or as the pure compound histological repair is immediately resumed. Some of these findings were confirmed by Muzzi, Lauber and Rosenfeld in 1938 made

histological studies of the vitamin C content of various tissues in the bodies of guinea pigs on low vitamin diets. When wound healing was in progress a decreased amount of vitamin C was found in the various tissues suggesting that it had been utilized in the healing process. In a recent experimental study Hunt found that collagen does not form in healing wounds of guinea pigs partially deficient in vitamin C and that the intracellular substance remains immature and of poor holding power. He concluded that vitamin C in good concentration is of the greatest importance in wound healing.

It would seem that there is ample proof many times confirmed that vitamin C is necessary for the formation of collagen in tissue repair and further that the development of tensile strength in wounds is retarded by a partial or complete vitamin C deficiency.

This report is concerned with a careful biochemical and histological study of wound healing associated with deficient vitamin C intake but with other factors maintained as constant as possible.

#### METHODS

Young guinea pigs were used, weight 300 to 450 grams at start of the experiment. Both males and females were included, being distributed evenly in control and vitamin C deficient groups. The basal scorbutogenic diet used in all experiments was arrived at by combining features of diets used by several previous investigators (13, 19, 21). Its composition is as follows: rolled oats, 40 per cent; skimmed milk powder heated, 30 per cent; wheat bran, 18 per cent; butter fat, 10 per cent; sodium chloride, 1 per cent; cod liver oil, 1 per cent.

The animals were kept on this diet plus an adequate oral ascorbic acid intake of 5 milligrams a day for at least a week before the start of the experiment. The controls were continued on this regimen throughout while the vitamin C deficient animals were given no ascorbic acid for one week and 0.2 milligram per day thereafter (Not 2 mgm. per day is the threshold for tooth protection according to Harris and Ray). The average of the weight curves was approximately the same for



Fig 1 Abdominal wounds in deficient and control guinea pigs on the 8th postoperative day. There is marked edema about the wound of the deficient guinea pig with heavy crusts still present. This presents a marked contrast to the wound in the control animal which appears quite healed.



Fig 2 Abdominal wounds in deficient and control guinea pigs on the 14th postoperative day. The stitches had been removed 5 days previously. There still are a few crusts present on the wound of the deficient animal and some thickening remains, while the wound of the control pig is soft, smooth and well healed.

the deficient and the control guinea pigs. Both groups gained until the day of the operation. They then showed a loss the day after operation. The downward trend was reversed from the 4th to the 6th day, after which they then continued to gain at about the same rate throughout the duration of the experiment.

The animals were operated upon 14 to 15 days after the start of the experiments. Mid-line abdominal incisions about 6 centimeters in length were made and sutured with silk. Nembutal anesthesia was used. The animals were sacrificed 4, 6, 8, 10, or 14 days later. Blood was obtained at this time for determination of plasma ascorbic acid and total protein. The blood was drawn from 5 to 10 hours after the last vitamin C was given. The plasma vitamin C value was determined by the method of Bessey, slightly modified. The plasma protein value was determined by the total nitrogen determination method of Pregl.

For the determination of wound strength, the entire belly wall was removed and the sutures all cut. Strips 1 centimeter in width (measured *in situ*) were cut perpendicular to the incision, by means of a sharp razor blade. The tensiometer was used to measure the

grams per centimeter length of wound, as read directly from the tensiometer scale. Four or five such strips were obtained from each animal and the average calculated. Thus the average strength over the whole length of the wound may be estimated. In this respect the method differs from that used by others who measured the pressure required to burst the wound open, thereby obtaining the strength at the weakest point. For the purpose of conducting the histological studies a 5 millimeter strip was taken from near the center of the wound.

The piece of excised wound for histological study was fixed in 10 per cent formalin and paraffin sections were prepared. Routine hematoxylin and eosin and Heidenhain's azocarmine were stains used in the preparations of slides. The last mentioned stain was of some value in comparing the amount of collagen present in the wounds, but most of the changes were present with the routine hematoxylin and eosin stains. In comparing the controls and the test animals we found great variations in healing of wounds which could be ascribed to inaccurate approximation, therefore, comparisons were made of representative guinea pigs in the control group and representative guinea pigs in the deficient group.

## RESULTS

There was a marked difference in the gross appearance of the wounds in those guinea pigs kept on diets rich in vitamin C and in those kept on a partially vitamin C deficient diet. This is in confirmation of Hunt's previous findings.

In the normal guinea pigs, healing progressed rapidly. The wounds were clean, there was no oozing of blood from the margins or about the sutures, and there was no edema about the wound. On section there was no thickening of the belly wall and no evidence of hemorrhage into the wound. They almost universally appeared well healed by the 6th to 8th postoperative day and by the 10th to the 14th postoperative day the incision was white and smooth (Figs 1 and 2).

In those animals fed vitamin C deficient diets, the wounds presented a very different appearance. Almost without exception there was edema along the suture lines with some redness. Heavy bloody crusts formed soon after operation and were almost invariably still present on the 8th to the 10th postoperative day. Although appearing well healed on the 14th day the incision was still hard and raised with some crusts still present. When the belly wall was sectioned it was found to be thickened and often presented a hemorrhagic appearance.

Microscopic study of sections of wounds in control and in partially vitamin C deficient animals were made and we are indebted to Dr. Mark E. Mann of the department of pathology for his aid in interpreting the histological data. This study revealed marked differences as early as the 4th postoperative day. In the control animal (see photomicrograph Fig. 3 (frontispace)) epithelial bridges were complete though the thickness of the epithelium varied in individual pigs. A slight exudation of serum, red blood cells, and neutrophils was found in the corium and between the muscle bundles. A moderate fibroblastic proliferation was evident in the deep portion of the corium, but only a few thin collagenous fibers could be seen. Numerous foreign body giant cells and focal collections of mononuclears were detected at the edges of the wounds. Examination of the slides of the 4

day deficient group (Fig. 4 (frontispace)) revealed the epithelium to be well healed. In the reticular portion of the corium and in the subcutis numerous pools of serum containing red blood cells and a few lymphocytes could be found. Fibroblastic proliferation was more marked than in the control animals, but collagen production was scant. The presence of a hemorrhagic effusion was constant in all deficient animals.

At 6 days the wounds of control animals (Fig. 5 (frontispace)) indicated progressive healing by an increase in fibroblastic proliferation, the production of some mature collagen and of numerous thin blue staining fibers was noted in the azocarmune stain. Collagen production appeared most marked in the corium but was almost as abundant in the muscle layers. At 6 days the wounds of deficient guinea pigs (Fig. 6 (frontispace)) showed a marked exudation of fluid containing red blood cells; the exudate was seen throughout the entire extent of the wound but was most marked in the reticular layer of the corium and in the subcutis. Proliferation cells were as numerous in deficient animals as in control animals, but collagen production was definitely retarded. We were unable to detect any differences in cellular proliferation about the muscle fibers or any increase in the number of giant cells.

Surfing differences in collagen production were evident when the wounds of control guinea pigs were compared with the wounds of deficient animals 8 days after operation. In many instances the wounds of animals in the control group (Fig. 7 (frontispace)) were found to be almost completely replaced by mature collagen, while the wounds of deficient animals (Fig. 8 (frontispace)) showed only small areas of collagen production. A marked proliferation of fibroblasts was evident in the deficient guinea pigs and only a moderate proliferation in the controls. The wound of almost all deficient animal showed small pools of serum and red blood cells separating the wound edges. These pools were usually present in the deep layers of the corium but could be found throughout the entire wound.

At 10 days the wounds of the control group showed collagen production continued beyond that of 8 days. The wounds of deficient

animals likewise showed at 10 days a marked increase in the amount of collagen present, and, furthermore, a decrease in fibroblastic proliferation. Only by careful examination could small pools of exudate be detected in the specimens from the vitamin C deficient animals. These pools were usually found in the corium. In both the control and the deficient groups the amount of cellular debris and of foreign body reaction was markedly diminished.

In the slides of the 14 day groups there was wide variation in the amount of healing. In the majority of the control animals the wounds were almost completely healed and showed some contraction. The wound sites were difficult to detect in the corium, for the collagen was dense and the fibrocytes apparently mature. In the muscle layers a large amount of collagen was present with only a mild cellular proliferation. In deficient animals at 14 days, good wound repair was seen in some, but in many the wounds gaped at various levels. Little effusion could be seen, but marked cellular proliferation was present in most instances. The amount of collagen present, judged by azocarmine stain varied with each animal, the maximum production was usually found in the corium.

In animals deficient prior to operation but given ascorbic acid daily after operation, it was found that healing was delayed during the first 6 days. Small effusions were found in some animals, and collagen production was postponed in all. By the 8th day after operation however, the wounds appeared almost as completely healed as those of the control group.

The plasma vitamin C levels found in normal animals are lower than those reported for guinea pigs by various other workers, who, however, used titration methods. According to King the lower values are more nearly correct. This method has been in use continually in the laboratory for specimens from human patients, and gives results in the normal range (0.5 to 2.0 mgm per 100 cc) when no deficiency is present. A small series of unoperated upon control animals gave results not significantly different from those for the operated upon animals. All the normal guinea

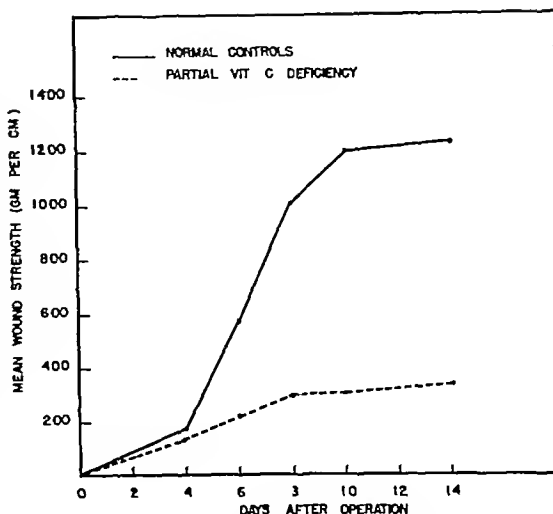


Fig. 9 Effect of partial vitamin C deficiency on wound healing in guinea pigs. The unbroken line represents the average of the tensile strength of 1 centimeter of wound in the 60 guinea pigs fed adequate amounts (5 to 10 mgm) of ascorbic acid daily. The broken line represents the average tensile strength of 1 centimeter of wound in the 40 guinea pigs fed deficient amounts (0.2 mgm) of ascorbic acid daily.

pigs had values above 0.05 milligram per 100 cubic centimeters, with two exceptions, and all those with deficiency had values below 0.05 with one exception.

Vitamin C intake	Plasma vitamin C
10 mgm a day	0.22 (average of 20)
5 mgm a day	0.13 (average of 40)
0.2 mgm a day	0.01 (average of 40)

The average plasma protein for 60 normal guinea pigs was 4.63 per cent and for 40 partially deficient guinea pigs it was 4.55 per cent. It is seen there is no significant difference between the two groups. The values are normal for guinea pigs (8). Therefore, the lower tensile strength of the wounds in the guinea pigs fed the partially vitamin C deficient diet is not due to decreased plasma protein.

Moisture determinations on segments of the abdominal wall were made after the tensile strength had been determined in a few cases. For 7 normal animals the average was 76.1 per cent ( $\pm 2.1$  per cent) and for 6 partially vitamin C deficient animals the average was 79.1 per cent ( $\pm 1.7$  per cent). Only 1 of the deficient animals gave a result lower than the highest control.

TABLE I.—EFFECT OF PARTIAL VITAMIN C DEFICIENCY ON TENSILE STRENGTH OF WOUNDS IN GUINEA PIGS

Number of guinea pigs	Amount of vitamin administered		Tensile strength of wound in grams per centimeter					
	Ascorbic acid, mgm. per day	Vitamin per day	On 4th day	On 6th day	On 8th day	On 10th day	On 12th day	On 14th day
60	10		60	27	18			
40			130	66	204	498	490	
20				37		177	79	
20	5-mg. to 15th postoperative day thereafter		103	240	31	22	267	
20	5-mg. to 7th postoperative day, 10-mg. thereafter		17	20	79	130	147	
	5-mg. to 7th postoperative day, 10-mg. to 10th day, 15-mg. thereafter			16	90			

The tensile strengths of the wounds in the guinea pigs kept on the vitamin C deficient diet and in the control animals showed a marked difference from the 6th day on. On the 4th postoperative day the differences were not significant. On the 6th day however the wounds of the control animals were more than twice as strong and by the 10th day had become four times as strong as those of the deficient animals (see Fig. 9).

A study of Table I will reveal that there is no significant difference in the tensile strength between those animals kept on the daily dose of 5 milligrams of ascorbic acid which is adequate for a guinea pig, and those kept on 10 milligrams daily which may be considered excessive dosage.

In the last line of Table I data are presented from a group of animals which received the usual deficient amount of ascorbic acid until the time of operation. On the day after the operation they were given 10 milligrams of ascorbic acid and from then on received a daily dose of 10 milligrams. On the 6th postoperative day the tensile strengths of the wounds of these animals, while not as great as those in the control guinea pigs, were definitely above those in the deficient animals, and by the 8th postoperative day had attained the level of the controls.

The graph summarizes the results. The heavy unbroken line represents the average for the 60 guinea pigs fed adequate (5 or 10 mgm.) ascorbic acid and the broken line represents the average for 40 guinea pigs fed 0.2 milligrams of ascorbic acid daily. Each point on the unbroken line is the average for 12 animals. Each point on the broken line is the average for 8 animals. The normal wounds reached the strength of the unoperated abdominal wall by the 14th day. However they frequently broke through elsewhere than at the wound after the 8th day. The wounds in the deficient guinea pigs always broke at the incision. The strength of the unoperated upon abdominal wall is the same in control and in deficient animals, being somewhere between 200 and 3000 grams per centimeter.

Several normal animals were allowed to heal for 2 weeks (5 or 10 mgm. vitamin C per day). At this time the wounds were well healed. The vitamin C was then withdrawn completely and the animals were allowed to develop scurvy of more or less severity. They were sacrificed after they had been losing weight for several days. The wounds appeared grossly to be in poor condition, with the characteristic hemorrhagic appearance but had normal strength. Only 3 animals survived for completion of the experiment.

Sections of tissue from 2 guinea pigs sacrificed on the 20th and 22nd days following withdrawal of vitamin C showed the wounds to be well healed and comparable to those of the control animals. The tensile strengths of their wounds were 248 and 1401 grams per centimeter of wound. The wound of the third guinea pig sacrificed on the 34th day after withdrawal of vitamin C contained a pool of serum between the muscle layers, and there was no appreciable decrease in the amount of collagen. This wound appeared comparable to those of the 3 and 0 day deficient animals and had a tensile strength of 880 grams per centimeter of wound.

Addition of 2 milligrams per day of lemon eriodictin to the diet of either normal or partially vitamin C deficient guinea pigs had no significant effect on wound healing (Table I). This substance is Sacet (Gyorgy) vitamin P or citrin, a flavone glycoside. It is claimed





# FREE FULL THICKNESS SKIN GRAFTS

## Principles Involved and Technique of Application

LOUIS T. BYARS, M.D. St. Louis, Missouri

THE advantages of transferring skin by means of free grafts rather than by tedious flap operations are obvious. In many circumstances it is imperative that flaps be used because the conditions under treatment require the transfer of a greater thickness of tissue than that possible by free grafts or because this is definitely the method of choice. The objections to the use of flaps (provided a better method is available) are the time period often required from beginning to completion of a repair, the number of operations necessitated, sometimes objectionable scarring of relatively exposed portions of the body, the chance of losing hard earned tissue from circulatory insufficiency after prolonged preliminary steps, the limitation of the available surface area practical to transfer, the sometimes "heaviness" of the transferred tissue which is at best difficult to eliminate (Fig. 1) and perhaps most disappointing of all the possibility of discovering after a long series of preliminary operations, that the area of the flap is inadequate. In dealing with many of the defects often treated by the use of flaps, the surgeon would gladly substitute free grafts of part or whole thickness skin if he had adequate confidence in his ability to get successful takes of the grafts.

For practical purposes, free grafts, other than pinch grafts, may be divided into two groups: those involving part thickness of the skin (Thiersch, split intermediate thickness, etc.) and those involving the complete thickness of the skin but not including any of the underlying tissue.

The problem of choosing the type of graft to be used must be settled by the operator's experience and judgment, the final selection often being made at the operating table. It is possible, however, to state some rules for this

choice as well as some advantages and disadvantages of each type of graft.

### THE SPLIT THICKNESS GRAFT

It is well to realize that the split thickness graft is not necessarily the tissue-paper-thin, ragged graft obtained in small scraps as often seen. It is possible to obtain it at will, given reasonable skill in cutting and a reasonable donor site, ranging in thickness from one-half the total depth of the skin to almost full thickness. A graft 12 inches long and 4 inches wide can often be obtained, and on one ideal subject grafts have been taken in one piece 30 inches long, the donor area extending from the scapula to the knee on the posterior body surface. The advantages of this type of graft are: (1) It takes very readily. (2) It may be applied with confidence to an open ulcerating wound which has been properly prepared. (3) It may be obtained very quickly. (4) Any available flat surface of the body may be used as the donor site. The thighs are the easiest sites for cutting, but the abdomen, buttocks, back, and upper arm are often used. (5) The donor site heals quickly, usually being completely epithelialized in 4 days. (6) If necessary, the same donor site may be used again after several months; this site for subsequent grafts is not as desirable as a fresh area but has, of necessity, in certain cases supplied three crops of skin. (7) The graft may be applied with relative speed. (8) Large areas of skin may be grafted at one operation.

The disadvantages are: (1) *Contraction and wrinkling.* If applied on a freshly created wound which is not underlain by a rigid base, the graft will undergo a great deal of contraction and wrinkling. If the area so grafted is acted upon by strong muscle action, such as in the axilla, arms, legs, etc., this contraction will relatively quickly be overcome and the wrinkling disappear (Fig. 2). In other



Fig 1 "Heaviness" may often result from the use of flaps in an attempt to relax contractures or replace skin. The preoperative photograph shows the patient after the application of three flaps to the neck and chin. Our operative plan included the use of as much of this material as possible since it was already present, consequently the neck flaps were thinned and left in place and were supplemented with a small area of skin graft. It was our opinion, however, that the flap on the lower lip and chin could never be thinned enough to reproduce the normally thin covering of this area, so this was replaced with a free full thickness graft from the thigh as shown.

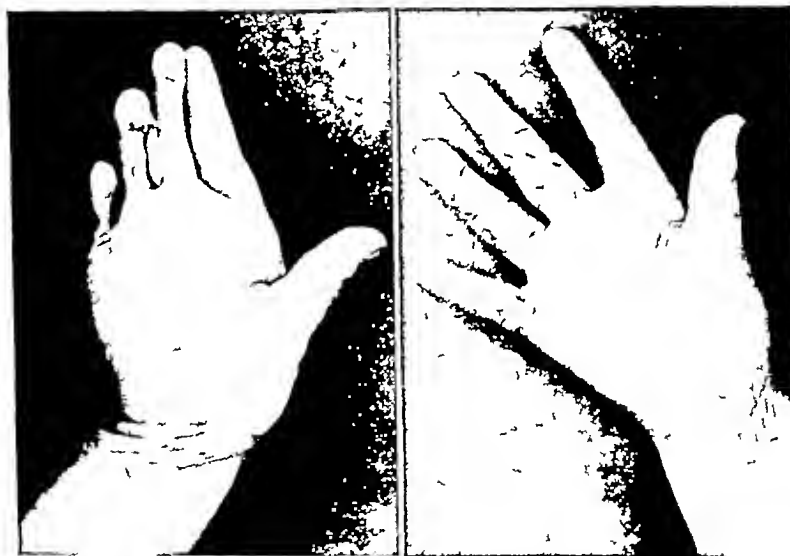


Fig 2 It is especially important to use full thickness skin on the flexor surface of fingers. Split skin grafts tend to contract considerably more than do full thickness grafts and this coupled with the anatomical fact that the flexor muscles are much more powerful than their opposing extensors often causes a partial return of the flexion deformity. This permanent contraction is less likely to happen when a split graft is used on the dorsum of a hand, because here the tendency for the graft to contract is opposed by the powerful flexor muscles. Full thickness grafts are shown 2 weeks after application, full correction of the deformity has been maintained.

areas where the graft is closely applied to muscle which is constantly exerting a pull on the graft, the same effect is obtained. The eyelids are an example of this. If applied to a freshly denuded wound on an akinetic area, such as a cheek or neck, the result is apt to be

disappointing. Oftentimes, the eventual result will be good, but several years may be required for sufficient relaxation to develop. If applied to a wound created by removal of the surface epithelium or granulations overlying a firm scar base, this wrinkling is minimized.



Fig. 3. Extreme deformities such as this, full correction cannot be done in one operation, and it is seldom practical to make the entire correction by the use of full thickness grafts. This deformity was related and covered with split skin grafts in two grafting operations. As usually occurs on the neck, an area of this graft remained very

rough and corded, although the take was as good in this area as elsewhere. This is shown in the middle photograph. The final photograph shows correction after full thickness graft had been applied to replace and supplement the rough split graft. Split graft operations are done by Dr. A. P. Blair.



Fig. 4. Many small blemishes about the face are too large for excision and suture and in these cases the full thickness graft of postauricular skin is near ideal. In this patient, the areas of scar tattooed with road dirt and oil, one on the upper lip and one on the left upper cheek, were excised and such skin grafts applied. The grafts are shown 6 months after operation. Grafts of this size and type can be applied with near certainty of take.

3. *Failure to match surrounding tissue in color.* The graft may become deeply pigmented or may lose its pigmentation. Often times this contrast is accentuated by tanning from ultraviolet rays. However the surface of the graft is such that it readily takes cosmetics, after its preliminary roughness disappears and the color may be so matched to the surrounding parts. Likewise tissue transplanted by a pedicle flap frequently has the

wrong color if taken from any part of the body other than the forehead and applied to the face. The skin color of the face contains red tones lacking in other parts of the body.

#### THE FULL THICKNESS GRAFT

The advantages of the full thickness graft over the split graft are: (1) It undergoes slight contraction and no wrinkling. This contraction relaxes in a few months, usually quicker



Fig 5 This case well illustrates the deformity of features which may result from a scar pull somewhat remote from the feature itself. Note the pulling down of the lobe of the ear, the corner of the mouth and the cheek itself. This pull on the cheek frequently results in a lower position of the lower eyelid and gives the involved side of the face a pathetic expression. Considerable relaxation resulted from incision across the scar and dissection without removal of any epithelium whatever. This relaxation is shown in the postoperative photograph taken 6 months after the insertion of a full thickness skin graft from the thigh.



Fig 6 A free full thickness graft taken from the inner surface of the upper arm and used to replace tattooed skin of the lower lip, chin, and cheeks. Below and just external to the right angle of the mouth is a scar on the graft representing an area of loss due to a small hematoma. Just below the lip border and to the left of the midline are the marks resulting from small areas of superficial erosion. Postoperative photograph taken 6 months after application of the graft. In such sites as this, the application of a pedicle flap is likely to result in too much "heaviness" in appearance (Fig 1).

than with a split graft. (2) The resulting surface often has a better appearance and texture.

The disadvantages of the full thickness graft are: (1) It is more difficult to secure uniform "takes" than with the split graft. (2) For this reason the surface area which may be transferred at one operation is limited. (3) Its removal creates an open wound at the donor site which does not heal spontaneously by skin regeneration as does the donor site of the split graft. This open wound can sometimes be sutured, if not, it is our custom to cover it immediately with a split graft. (4) It cannot be applied to ulcerating wounds with any

degree of confidence. (5) It is slow and tedious to take from its donor site. (6) It is tedious to apply and requires much more exacting care both in its first and subsequent dressings than does the split graft. (7) The color of the full thickness graft, as the color of a flap or split graft, may not match. The postauricular skin, if a small graft only is needed, usually approximates the face skin in color because it contains the necessary red skin tone.

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Fig 7. The preoperative condition was represented by this, sick scar of the cheek. The scar, because of its texture, could not take cosmetics. In addition, due to its contraction, there was flattening of the cheek. The middle photograph shows the wound 3 weeks after the removal of the scar thus permitting the wound to expand, and the application of a full thickness graft from the thigh. Along the anterior border of the graft is an area of loss resulting

from small bacteria, just above. Its center is an area of superficial erosion resulting from intrinsic infection of the graft.

The photograph on the right was taken 6 months after operation. In the patient during cover mark. The roughness of the scar from the area of loss is shown. This may be expected to improve with time. The contour of the face is considerably improved.

to clarify terminology, and to point out certain characteristics of different grafts so that the proper selection of the type of graft to be used may be made. A point of emphasis is that a split thickness graft should be used in preference to a full thickness graft unless there is a distinct reason to use the more difficult graft (Fig 3).

**General factors.** It is essential that the patient's condition of general health be as good as it is possible to obtain before operation. Operation should be definitely postponed in the presence of any pus, infection of the skin

or any acute respiratory infection. In the face of general debilitation it may be better judgment to substitute a simpler, quicker split graft repair with the idea of later reoperation, if necessary, with the use of full thickness grafts (Fig 3).

**Size of graft practical to apply.** Small full thickness grafts take much more readily than do the large ones (Fig 4). Important reasons for this are the greater ease with which a small volume of skin may be nourished by osmosis and diffusion of gases and salts while developing its blood supply, and the greater



Fig 8. Contracture of neck and cheek resulting from an acid burn. A great deal of keloid scar is present. Such keloids may result entirely from infection of the primary wound and the irritating effect of tension on the resulting tight scar. This is true in the case in Figure 4. In addition to the factors mentioned this patient seemed to have an inherent tendency to form keloid scars. Three full thickness grafts are shown. Multiple grafts are necessitated by the severe string contraction of the scar borders of the grafts reducing their area. Note the effort which has been made to prevent critical scar on the front of the neck.

Fig 9 Illustrating the successful application of a full thickness skin graft to the inside of a nostril to replace lining of the nostril previously lost by infection. The contraction of the scar had pulled the alar border up in a notch as shown and caused considerable diminution of the breathing space. By dissection of the scar the alar border was brought down in place. A full thickness graft of postauricular skin was carefully sutured in the defect within the ala, the interrupted sutures were left long enough to tie over a gauze form to produce the proper pressure and tension on the graft. There was a full take of the graft with correction of the deformity as shown. Photographs taken 6 months later revealed no further contraction of the area.

The application of a split thickness graft here simply by the packing into the nostril of a large square of skin in "tent" fashion would have been much more simple, but the tendency of such a graft to contract afterward would probably have given an unsatisfactory final result. Postauric



ular skin was chosen because its thinness makes its "take" more certain.

facility with which it may develop a blood supply. Another factor is the increasing difficulty with the larger graft of fulfilling the other technical requirements of smooth recipient bed, uniformly thin skin for the graft, accurate application of the graft and proper fixation after application. Thus, on the neck, a graft of moderate size may be applied with excellent chance of success. If this graft is made larger, one border may run from the neck up over the body of the mandible and its end may cross the constantly moving thyroid cartilage, thus adding some additional hazard (Fig 5). It is sometimes better to apply two grafts at separate operations rather than to attempt too much at one. Occasionally a contracted wound will open up to unexpected proportions or the relaxation will necessitate a rougher recipient

base than is desirable for a full thickness graft. In such circumstances it is better to apply a thick split graft, later supplementing or even replacing a part of this with a full thickness graft if necessary (Fig 3). A graft which is too large to apply to one area with certainty of "take" may not be too large for another. For example, the dorsum of the hand, wrist, and forearm represents a sizable area, but it is smooth and regular and a large graft here may be expected to do better than one of the same surface area applied to the front of the neck and covering the thyroid cartilage, the supraclavicular depression, and extending down over a movable clavicle.

*Recipient site.* The area to be grafted normally results from one of two procedures. It may be the defect created by the removal of



Fig 10 Scar contracture causing considerable distortion and tightness of left upper lip and cheek. Vermilion border of left upper lip was pulled up to the level of the ala. The remainder of the scar of the face was of fair quality and could be adequately disguised by the use of cover mark. The contracture of the lip was dissected free and thoroughly relaxed, thus removing some surface scar. The defect was filled with a free full thickness graft of thin skin. Patient is shown 4 months after operation wearing cover mark to match the graft to surrounding skin color.



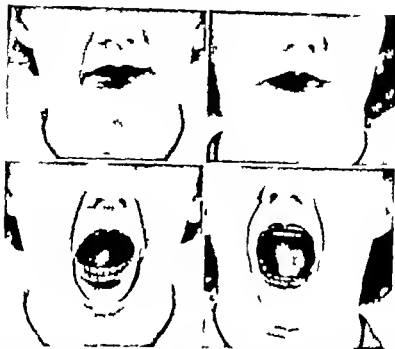


Fig. This represents every difficult problem as to proper procedure. There is generalized scarring and tightness of both cheeks, emphasized especially in the open mouth photograph. Instead of an attempt being made to replace the scar, likely an insert of full thickness skin, as placed across the chief line of tightness on each cheek, actually very little of the surface scar, as replaced. This operation gave considerable relaxation of the face and improvement in appearance. A wider replacement of surface scar and larger graft might have given a better result. Patient is photographed early, covering mark, to match the graft to the surrounding skin color.

some pre-existing lesion such as a portwine stain, hair-bearing mole, or surface scar (Figs. 6 and 7) or it may occur as a result of incising and relaxing a contracture (Figs. 5, 10, 11, 12, 13). In either case the base of the wound should be dissected so as to be smooth, without pits and holes, thus permitting all parts of the under surface of the graft to be in contact with raw surface with the minimum of crevices to harbor small hematomas. The borders of the defect should be so trimmed as to be fairly regular inasmuch as irregularities make more difficult the accurate fitting of the graft. It is of the utmost importance that hemostasis be complete, bleeders being ligated with No. 000 or finer silk, never with catgut. The shape of a recipient wound is often important in determining ultimate smoothness of the graft. A graft applied to a movable surface should not have a straight border along the line of tension

because a prominent, irritated, and contracted scar is likely to develop. The graft border should especially not extend straight down the neck (Fig. 8). This principle is well known and understood in planning operative incisions but may be overlooked in applying grafts.

**Donor site.** Little is definitely known about the mechanism whereby a graft assumes its own circulation. It is known however from the transplantation of refrigerated skin and from survival of entire extremities after periods of reduced metabolism produced by long applied tourniquets and local refrigeration that tissue may have an indefinite period during which it receives very little nourishment and still survives provided the circulation is established within the dead line. It is logical to assume that there is a period following the application of a graft when it is



Fig 12 This represents one of the most difficult types of cases to handle because much of the disfigurement present is due to generalized scarring of the skin, the skin being of fair quality and not involved in any marked contracture. The forehead and right cheek illustrate this point. Sometimes it is difficult to decide whether a better or poorer ultimate result would follow widespread replacement of this scarred skin. In the case here illustrated, the contracture producing the ectropion of the lower eyelid was relaxed and a full thickness skin graft of postauricular skin applied. The contracture of the left upper lip was relaxed by dissection, some of the scar of the left cheek excised, and the defect filled with a full thickness skin graft from the thigh. A better result could have been obtained if more scar adjacent to the nose had been excised and a larger graft inserted.



Fig 13 Moderate neck contracture from a burn scar. This had previously been grafted unsuccessfully. The scar was excised and the wound relaxed by dissection. The defect was covered with a full thickness skin graft from the thigh. There was an area of loss the size of a five cent piece

near the lower border of this graft in the midline of the neck. This resulted from a small hematoma. The area was covered with a split graft 3 weeks after the first operation and left very little scar. The postoperative result is shown 1 year later.

entirely deprived of nourishment. Following this there must be another period during which it receives some nutrition from its base

by osmosis and diffusion of carbon dioxide, oxygen and blood salts. Subsequently, the blood vessels from the base gradually unite

Next to the graft is smoothly applied fine meshed gauze impregnated with 4 per cent mercuric iodine in vaseline or 1:2000 mercuriolate ointment. There is sufficient ointment uniformly distributed to fill the interstices of the gauze; an excess is carefully avoided and maceration does not result under these circumstances. Next to this may be placed several layers of dry gauze with care to avoid wrinkles and folds resulting from one piece of gauze overlapping another. Instead of this dry gauze it is often better to strip thin smooth sheets of cotton from a pad sterilized as it comes from the roll, the pad being moistened without wadding. These moist cotton sheets have a more smooth uniform surface than does gauze and when applied next to the greased gauze layer covering the graft have fewer irregularities and wrinkles. An additional advantage is that the small amount of postoperative bleeding after impregnating the moist cotton and drying forms with the cotton a very firm splint, much like crinoline. Next is applied a padding of gauze or machinist's waste and sea sponges. The dressing is bulky enough to help splint the area and it is applied with pressure. The exact and optimum pressure to be applied is unknown, and if it were known the difficulties in applying and maintaining this exact pressure would render the performance inaccurate when dressing difficult areas. It is possible to apply too much pressure causing ischemia, when dressing a graft against such a surface as a skull, leg, or arm on other areas it is difficult to apply too much pressure. However it is desirable to have a firm, springy pressure dressing and anything over and above this cannot be of further value and may be harmful. Wrinkles in gauze or coarse folds of overlapping gauze are carefully avoided.

One eyelid grafts, small grafts on the face and often large neck grafts; primary fixation is obtained by applying exactly the same type of dressing but leaving the interrupted sutures long enough to tie over the dressing pad (Fig. 9). Care must be taken not to tie these too tightly because the tension and pressure may become too great. This type of dressing is usually supplemented with additional covering bulk and supportive dressings.

It is of great importance not to create a defect with a part of the body in an exaggerated position, apply a graft, and then fail to maintain the part in this same position during the application of the dressing and for the next week. If for example a neck contracture were liberated the head gradually being turned into a position of overcorrection, the graft applied and then the head allowed to assume its normal position all of the carefully executed factors for pattern tension, and accuracy of fit would be negated. If a part is to be held in a position of exaggeration, this must be assured by the dressing; plaster of Paris being used if necessary or for hands, a previously arranged wire or aluminum splint.

It is desirable to have the grafted area as completely at rest as possible. Thus if a graft overlies the thyroid cartilage the swallowing movements can be minimized by nasal tube feedings. If on an extremity neighboring joints are immobilized.

*Subsequent dressings.* A great deal of harm can be done to a graft if it is not dressed soon enough. Small grafts such as those applied to the eyelids can be safely dressed on the fourth day if there is any real reason to do so, such as irritation of the covered eye. With this exception all full thickness grafts are dressed on the fifth or sixth postoperative day. By this time the graft has definitely developed its circulation and it is entirely safe to expose it. In addition, the patient is usually impatient with the tight rigid itchy dressing and the change gives him great relief. If there is a hematoma under the graft that part of it is lost (Fig. 7). If an ordinary wound infection has resulted the graft is lost. These should be avoidable circumstances, usually. Otherwise at the first dressing the graft should be a fairly uniform pink color. There may still be present a few rapidly fading black and blue spots. A full thick eye graft viewed in 48 hours has a large portion of its area thus mottled. In spite of precautions to avoid it there have been fold or wrinkles in the dressing, each of these may have caused a thin superficial blister under the surface epithelium, and these may often be expected to cause superficial ulcerations. The graft is redressed, the same general technique being used as at the initial dressing. A daily

# SUMMARY OF RESULTS IN 154 CONSECUTIVE GRAFTS

Small grafts—3 square inches or less in area

Total number 99  
Number totally lost 1\*

Medium sized grafts—approximately 3 to 5 square inches

Total number 43  
Number totally lost 1†

Large grafts‡—approximately 5 to 18 square inches

Case	Area grafted	Immediate result	Cause of loss	Final result
1	Cheek	Small area of ulceration at graft border	Hemato-ma	Slight permanent scarring. Considerable improvement over preoperative condition
2	Cheek lower lip and chin	Area size of dime of full thickness loss. Several small areas superficial erosion	Hemato-ma. Intrinsic infection	Some permanent scarring but very worthwhile result (see Fig. 6)
3	Neck	Area size of 5 cent piece superficial loss	Hemato-ma	Area of loss regrafted. Good final result (Fig. 13)
4	Neck	2 areas of 4 mm diameter each superficial loss	Intrinsic infection	Slight permanent scarring. Good result
5	Neck	1 area size of dime superficial erosion	Intrinsic infection	Good result
6	Neck	No loss		Good result
7	Cheek	1 area 3 mm diameter surface erosion	Intrinsic infection	Good result
8	Neck	2 areas 5 mm diameter superficial erosion	Intrinsic infection	Good result
9	Neck	1 area 4 mm diameter	Intrinsic infection	Graft good appearance. Borders formed keloid scars. Patient known to have tendency to keloid
10	Neck	2 areas 4 mm diameter	Intrinsic infection	Graft good appearance. Borders formed keloid scars. Patient known to form keloids (Fig. 8)
11	Neck	2 small areas superficial erosion	Intrinsic infection	Graft good appearance and worthwhile result. One graft border developed heavier scar than usual
12	Fore head	No loss		Good result

\*No other loss considered extensive enough to mar final appearance of graft seriously

†In addition 1 graft had 5 percent of its area involved in an ulcer and 4 grafts had small areas of ulceration at borders of graft which were of sufficient size to leave additional scar but still gave worthwhile improvement over original condition. A number of other grafts had small areas of superficial erosion which did not seriously mar final appearance of graft.

‡Of a total number of 12 large grafts there were none completely lost. However there was a definite increase in the incidence of superficial erosions and for that reason a more detailed description is given.

§By intrinsic infection is meant a destructive infectious process arising from skin organisms which are within the skin itself and which become active during the period of low vitality before the skin graft has completely developed its circulation and resistance.

dressing is performed thereafter until the graft is out of danger. The reapplication of sea sponges, or equivalent pressure, is continued until the graft is 2 weeks old.

There is one important reason for the changing of dressings as early as the fifth or sixth day and the subsequent daily dressings. All skin contains bacteria, not normally virulent, which are in the pores and on its surface. A new graft, although its take is perfect, is struggling to maintain life and has none of the normal facilities for maintaining resistance. A full thickness graft must be 3 to 4 weeks old before it is strong enough to perpetuate new skin. During this period the low-grade bacteria present can initiate erosions of the graft. These most often begin in the tiny epithelial blisters previously mentioned, but may begin at any point. A carelessly applied dressing, even as late as the second week, can file on the graft and cause sufficient surface irritation to initiate such an ulcer. Early first dressings and daily change thereafter with removal of secretions, applications of sulfathiazole powder to any breaks, and the application of a mildly antiseptic ointment as before described tend to prevent and check these erosions, which, if unchecked, can destroy an entire graft or result in a rough surface after eventual healing (Figs. 6 and 7). The ordinary graft, with average success of take, should have a very small proportion of its surface area involved in any ulceration or infection.

*Chances of success* It is impossible to express in percentages the chance of success of full thickness grafts, because this will vary so much with the individual case. The small grafts such as those applied to eyelids or small areas about the face can be undertaken with the same expectation of success that one would expect for the healing *per primam* of any type of clean operation in the same area. The number of failures will increase with the magnitude of the correction undertaken. Realization of the dangers and the avoidance of the pitfalls should reduce the chance of failure to such a point as to justify the attempt. If a full thickness graft does, unfortunately, fail to take, the area should be made clean as soon as possible by removal of the dead graft, and the frequent application of

constantly wet pressure dressings. Between the third and fourth postoperative week the wound should be regrafted with a thick split graft, the granulations but not the underlying plane of scar being excised. The graft so applied has a major chance of success (Fig. 13). The result will suffer chiefly in that some of the relaxation gained at the first operation has been reduced by the interval of healing. Even if two operations are necessary to obtain the result hoped for in one operation, often the patient has a better result more easily obtained than if the correction had been made by the use of flaps. The same is all the more true if one full thickness graft must be supplemented by others to gain full relaxation of a deformity such as a neck contraction because then the total area of transplanted skin is greater than that easily available as flaps.

*Subsequent course* On a kinetic area such as the cheek, it may take several months or a year for a graft to become soft and pliable and for its bordering scar to become minimal. If a graft border is subjected to irritating tension, it will keloid as would any incisional scar. This means that its shape should be so planned as to avoid this and that the size must be such as to give relaxation. Sites of individual spots of full thickness or surface loss may in some instances produce unsightly scars but are usually so small as to heal without permanent blemish. In individuals known to produce keloids because of an inherent tendency and not because of mechanical factors of tension, infection, and irritation (Fig. 14) the graft borders are treated with radium 2 to 3 weeks after operation in the hope of minimizing this keloid.

# PRINCIPLES WHICH SHOULD GOVERN THE LOCAL USE OF THE SULFONAMIDE DRUGS

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**C**LINICAL studies have demonstrated that the sulfonamide drugs applied locally are of value in the control of certain infections (1, 3-18, 24, 27, 32-35). In this paper are assembled certain facts about the action of these drugs on controlled quantitative studies by the method of human marrow culture (30). Deductions are made from these facts as to the method of application which should be most satisfactory, with the hope that these suggestions may serve as a guide to those who have clinical facilities for controlled comparison of the suggested method with other methods of use in the various infections.

## METHOD

About 10 cubic centimeters of marrow or leucemic blood was introduced into a vaccine vial containing about 25 cubic centimeters of citrated balanced salt solution. After manipulations to remove the non-nucleated erythrocytes there was about 60 cubic centimeters of culture containing about 120,000,000 living, nucleated, human cells in a medium consisting of 35 per cent ascitic fluid and 65 per cent balanced salt solution, similar in composition to cerebrospinal fluid. This was thoroughly mixed and divided into two equal parts in vaccine vials, all manipulations being made with syringe and needle through vaccine caps covered with 70 per cent alcohol. One of these lots was then inoculated with a small number of organisms and the other with a large number. The vials were thoroughly mixed, and samples were removed for the initial pour plate colony count. Each of these vials was again mixed and an equal volume from each

was transferred to each of five 30 cubic centimeter vaccine vials which contained respectively nothing, 1 gram of sulfanilamide per 100 cubic centimeters of final volume, 1 gram of sulfapyridine per 100 cubic centimeters of final volume, 1 gram of sulfadiazine per 100 cubic centimeters of final volume, and 1 gram of sulfathiazole per 100 cubic centimeters of final volume. The ten vials were then thoroughly mixed and placed in the incubator together. At intervals samples were withdrawn for pour plate colony counts, smears, and determinations of the drug concentration. Paraaminobenzoic acid in the proportion of 5 milligrams per 100 cubic centimeters was present in each pour plate, because this drug has been shown to inhibit the action of the sulfonamide compounds. Quantitative determinations of the drugs with the photoelectric colorimeter by the method of Bratton and Marshall were made on the supernatant fluid after centrifugation from each culture. The smears were stained with Wright's stain, and they were examined for the condition of the cells and for the number of organisms. The number of organisms compared well with the colony counts. The *Staphylococcus aureus* was used in two such experiments, and the *Escherichia coli* was used in one.

## RESULTS

The results are shown in Tables I to III. Note from Tables I to III that none of these drugs is as effective against a large inoculation as against a small inoculation, that sulfanilamide in the concentration attained uniformly killed all living nucleated cells, that a considerable period of time, from 40 to 70 hours, is required for the action of the drugs when they are effective, that sulfathiazole and sulfanilamide are more effective in the concentrations attained than sulfadiazine and sulfapyridine, and that the solubilities of these

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TABLE I.—COMPARATIVE EFFECTIVENESS OF MAXIMUM CONCENTRATIONS OF SULFONAMIDE DRUGS ON SMALL AND LARGE INOCULATIONS OF THE STAPHYLOCOCCUS AUREUS

Hours		16	32	48	64	72	C%.
Control	70 <sup>a</sup> 15,000	47 41	670,000,000 <sup>a</sup> 1,250,000,000	47 4.2	1,000,000,000 <sup>a</sup>		
Sulfanilamide, gm. per 100 c.	70 1,000	400,000 120 41	1,500,000	434 1.09 41	950,000	10 <sup>a</sup> 1,200,000	Delayed Infection
Sulfapyridine, gm. per 100	70 15,000	35 47 30 41	45,000,000	33 47 24.1	100,000,000	750,000 90,000,000	Delayed Infection
Sulfadiazine, gm. per 100	70 15,000	80 47 77 41	1,700,000	7 47 71 41	150 61,000,000	100,000 450,000,000	Delayed Infection
Sulfathiazole, gm. per 100 c.c.	70 15,000	170 47 170 41	500,000	150 47 79 41	300,000	1,500,000	Delayed Infection

<sup>a</sup>Colony per c.c.<sup>1</sup>Milligrams of drug per 100 c.c. of suppurative fluid.

drugs in the marrow culture medium at 37 degrees C. is for sulfanilamide about 100 milligrams per 100 cubic centimeters, for sulfathiazole about 160 milligrams per 100 cubic centimeters for sulfadiazine about 80 milligrams per 100 cubic centimeters, and for sulfapyridine about 55 milligrams per 100 cubic centimeters. Many other experiments by the marrow culture technique (19-31) have shown that in the concentration of 5 to 10 milligrams per 100 cubic centimeters, the concentration obtainable if the drugs are given by mouth, sulfathiazole is the most effective with sulfadiazine and sulfapyridine next in effectiveness and sulfanilamide the least effective against the *Staphylococcus aureus*, the beta hemolytic streptococcus of the Lancefield group A the *Streptococcus viridans*, the *Escherichia coli*, the *Salmonella schottmuel-leri*, the *Eberthella typhosa*, the *Neisseria gonorrhoeae*, and many different strains of different types of pneumococci. In marrow cultures para aminobenzoic acid procaine hy-

drochloride and, presumably related local anesthetics inhibit the action of the drugs of the sulfonamide group. Neocarsphenamine (23-26 29) in a concentration of 75 to 200 gamma of arsenic per 100 cubic centimeters is more effective than any of the sulfonamide drugs against staphylococci and many strains of the *Streptococcus viridans* and beta hemolytic streptococcus.

#### OBJECTIVES OF LOCAL SULFONAMIDE THERAPY

The objectives of local therapy with the sulfonamide drugs are to prevent infection where infection is minimal or potentially present to prevent the spread of infection already present, to eliminate infection already present, to avoid local damage to tissue cells, to avoid absorption of amounts of drug which might be toxic, to reduce the number of organisms present in the local area of infection before application of the drug to a number which can be controlled by the concentra-

TABLE II.—COMPARATIVE EFFECTS OF MAXIMUM CONCENTRATIONS OF SULFONAMIDE DRUGS ON SMALL AND LARGE INOCULATIONS OF THE STAPHYLOCOCCUS AUREUS

Hours		16	32	48	64	72	C%.
Control	0.30 <sup>a</sup> 1,000	47 41	300,000,000 <sup>a</sup> 600,000,000	47 4.2	300,000,000 <sup>a</sup>		
Sulfanilamide, gm. per 100	0.30 0.1,000	0.20 47 0.10 41	30,000 450,000	1.1 47 1,000 41	100,000 20,000	950 47 1,000 41	Delayed Infection
Sulfapyridine, gm. per 100	0.30 1,000	10 47 30 41	400,000 15,000,000	24 47 21 41	450,000 950,000,000	30 47 11 41	Delayed Infection
Sulfadiazine gm. per 100 c.c.	30 0.1,000	77 47 77 41	500 1,000,000	82 47 41 41	10,000 1,500,000	30 47 41 41	Delayed Infection
Sulfathiazole, gm. per 100	0.30 0.1,000	46 47 143 41	500 1,000,000	90 47 20 41	75 10,000	47 47 120 41	Delayed Infection

<sup>a</sup>Colony per<sup>1</sup>Milligrams of drug per 100 c.c. of suppurative fluid.

TABLE III—COMPARATIVE EFFECTIVENESS OF MAXIMUM CONCENTRATIONS OF SULFONAMIDE DRUGS ON SMALL AND LARGE INOCULATIONS OF PSCHIRICHIA COLI

Hours	0	17	20	40	44	70	Cells
Control	2,400* 650 000	0 0† 0 0†	4 000 1 200 000 000	0 0† 0 0†	1 000 000 000		
Sulfanilamide 1 gm. per 100 c.c.	2 400 650 000	736 0† 752 0†	160 1 600 000	1 000 0† 1 036 0†	35 100 000	120 1 000 000 000	Destroyed Destroyed
Sulfapyridine 1 gm. per 100 c.c.	2,400 650 000	56 6† 53 6†	135 (4 000 000)	59 8† 58 8†		160 000 1 000 000 000	Intact Intact
Sulfadiazine 1 gm. per 100 c.c.	2 400 650 000	83 3† 83 3†	45 28 000 000	81 0† 65 1	300 45 000 000	1 000 000 1 000 000 000	Intact Intact
Sulfathiazole, 1 gm. per 100 c.c.	2 400 650 000	16 0† 148 0†	500 10 000 000	156 0† 148 0†	350 75 000 000	2 500 1 000 000 000	Intact Intact

\*Colonies per c.c.

†Milligram of drug per 100 c.c. of supernatant fluid

tion of the drug which can be attained, to maintain an adequate concentration of the most effective and least toxic drug for an adequate period of time to eradicate completely the infection, to apply the drug in such a way that an adequate concentration is attained immediately and the drug is in contact with all the organisms, and to avoid introduction locally of any substance which would inhibit the action of the drug.

To attain these objectives in the light of the facts experimentally determined, the following general principles seem logical. There are two major indications for local use of these drugs. For prophylaxis of infection the sulfonamide drugs should be applied locally as soon as possible after any break in continuity of tissue in a potentially infected area after removal of any necrotic tissue and cleansing of the wound. For treatment of local collections of pus due to any organism against which these drugs are effective, local application should be made as soon as possible after an adequate blood level of the effective drug is attained, the pus and necrotic tissue have been removed by debridement and surgical drainage, and the number of organisms has been reduced by irrigation with a saturated solution of the drug in 0.85 per cent saline.

The drug of choice for local application will prove to be, except in rare instances, sulfathiazole. It is less toxic locally than sulfanilamide and more effective than sulfapyridine or sulfadiazine, and its lower solubility insures maintenance of an effective concentration locally for a longer period of time than

would be true for an equal amount of sulfanilamide with less danger of producing an excessively high blood concentration. Sodium sulfathiazole should not be used locally, since it is so alkaline that it is likely to be irritating and produce tissue damage and since on neutralization by tissue fluids sulfathiazole is precipitated, so it has no advantages over application of the powdered sulfathiazole.

The administration of sulfathiazole or sulfadiazine by mouth or the intravenous administration of their sodium salts or of neoarsphenamine to attain an adequate blood level will eliminate the old contraindication to early operation, because this will take care of the small number of organisms which might be disseminated by early operation. By avoiding infiltration with local anesthesia, inhibiting drugs will not be introduced. Surgical drainage of any collection of pus with the removal of necrotic tissue and rinsing with saline saturated with sulfathiazole will eliminate temporarily the large number of organisms and will assure that there will be a saturated solution of the drug in contact with the organisms immediately. The application then of the finely powdered drug in quantities sufficient to maintain a concentration for at least 72 hours assures that the concentration will be maintained and that solution of the drug will take place rapidly to replace that which is absorbed. Closure without drainage insures that any air present will be promptly absorbed and that the fluid in which the drug is dissolved will then contact all surfaces. If drains are left in, air will be present with a resultant fluid level, and on the surface not



in contact with the drug the organism will multiply in large numbers and will then invade the areas in which there is an adequate drug concentration.

For oral use sulfathiazole should be the drug of choice except when there is risk of meningitis or intolerance to sulfathiazole. In the latter case, sulfadiazine should be the drug of choice. The sodium salts of these drugs should be used intravenously for the first dose when immediate operation is indicated or when the patient cannot take oral medication. Neosarsphenamine should be used intravenously exactly as previously described (24, 25, 26, 29) in serious staphylococci or beta hemolytic streptococci infections.

#### PREPARATIONS AND APPARATUS

It is convenient to have the following preparations and apparatus in stock for oral use: 0.5 gram tablets of sulfathiazole and sulfadiazine for intravenous use: sterile ampuls of sodium sulfathiazole solution and 0.15 gram ampuls of neosarsphenamine from which the solution may be freshly prepared each time an intravenous injection is to be given. For local use the bulk finely powdered sulfathiazole is satisfactory for most purposes. Ordinarily it need not be sterilized further. For intracranial or intraspinal use sterile sulfathiazole powder in ampuls is desirable. This may be prepared by placing 3.0 to 4.0 grams of the powder in pyrex test tubes or ampuls, drying it at about 85 degrees C. for 12 hours, sealing the ampuls while hot and then autoclaving the ampuls for one half hour at 10 pounds pressure at 110 degrees. For application to open wounds and in the peritoneal cavity it is convenient to have 10 to 20 grams of sulfathiazole powder kept in sterile metal salt shakers. For application to the nose, throat and through sinus windows or to large surfaces a powder blower filled with sulfathiazole powder is most convenient.

For application of the powder into tooth sockets, penetrating wounds or sinus tracts, various sizes of metal tubes fitted with plungers (8) are most satisfactory. To use these the plunger is withdrawn and the tube is punched into the dry powder until the amount desired is in the tube. The tube is then in-

serted into the sinus pocket and the powder is forced out of the tube with the plunger as the tube is withdrawn. For application to superficial lesions when there is a tendency of the dressings to stick, an ointment made by incorporating 10 grams of the powder in 100 grams of aquafor is most satisfactory. For irrigation a fresh saturated solution of sulfathiazole in sterile 0.85 per cent saline should be prepared before use by heating the saline to boiling and adding about 15 grams per liter of the powder and mixing until it has cooled to body temperature. For injection into the nasal accessory sinuses after irrigation with saline solution saturated with sulfathiazole a freshly prepared 10 to 20 per cent suspension of the powder in one of the water soluble lubricating jellies, such as Lubritine K 3 Jelly or Luxo is best. The same suspension may be used in the eye intraurethrally or applied to the cervix inside a contraceptive diaphragm. It may be used instead of the ointment for skin lesions when the drying action of the powder is too great.

#### SPECIFIC RECOMMENDATIONS

Since attention to details and the correct sequence of steps are important, these specific recommendations are given as examples of the recommended therapy in each of a number of different types of conditions. From these examples, application to other conditions should be obvious.

**Traumatic injury.** For fresh wounds within an hour of the time of injury the wounds should be cleaned by the usual methods. The necrotic and devitalized tissue should be removed, and the wound irrigated with saline saturated with sulfathiazole. The sulfathiazole powder should be sprinkled or blown onto each surface just before coaptation. The wound is filled with the powder and sutured without drainage.

Penetrating wounds should be irrigated with saline saturated with sulfathiazole and packed loosely with sulfathiazole powder, tube and plunger of appropriate diameter being used.

If the wounds are more than an hour old or are grossly contaminated the patients should be given sulfathiazole + sulfadiazine by mouth to obtain an adequate blood level.

or sodium sulfathiazole should be given intravenously for the first dose if the wounds are of major importance. The wound should be opened, drained thoroughly, rinsed with saline saturated with sulfathiazole until the fluid returns clear, and then packed with sulfathiazole powder. The wound should be closed without drainage. Sulfathiazole should be continued by mouth until 3 days to a week after the temperature is normal, in doses sufficient to maintain a blood level of 5 to 8 milligrams per 100 cubic centimeters. Sulfadiazine should be substituted if there is toxicity from sulfathiazole or danger of meningitis. It is probably not safe to depend on sulfathiazole powder alone for prophylaxis against tetanus in penetrating wounds, so the usual tetanus prophylaxis should be used too.

*Lesions of the skin and subcutaneous tissue*

In epidermophytosis of the feet, or so called "athlete's foot," sulfathiazole powder used as a dusting powder from a salt shaker is very effective in clearing up secondary infections, although whether it will clear up the epidermophytosis itself is not yet established. In impetigo it should be used orally and by local application of the powder suspension in lubricating jelly or ointment after the crust is removed. Any ulcerating lesion, not due to syphilis or tuberculosis, may be benefited by the local application of the powder in lubricating jelly or ointment. This is particularly true in ulcerating secondarily infected cancer, which first should be cleansed and débrided, then rinsed with saline saturated with the drug followed by application of the powder or suspension in lubricating jelly. With furuncles or carbuncles, it is desirable to give the drug by mouth until an adequate blood level is obtained. Then the lesion should be opened as soon as free pus is evident. The pus should be rinsed out with a stream of saline saturated with the drug and the cavity filled with the powdered drug. Except when there is involvement of the upper lip or nasal mucosa or if there is already a blood stream infection, sulfathiazole by mouth need not be continued for more than 3 or 4 days after the furuncles are opened. If there is a furuncle in the upper lip or nasal mucosa or if the furunculosis is associated with a bacteremia, one unit dose of

0.8 milligram per pound of body weight of neoarsphenamine is given intravenously every 4 hours for the first day and one unit dose every 8 hours thereafter for 9 days or until a week has elapsed from the last fever. Sulfadiazine is given by mouth in doses sufficient to maintain a blood level of 10 to 15 milligrams per 100 cubic centimeters. Both the first dose of sulfadiazine and neoarsphenamine should be given before the furuncle is opened and treated as here described.

*Eye lesions* In gonorrheal ophthalmia, sulfathiazole is given by mouth to maintain a blood level of about 5 milligrams per 100 cubic centimeters and a continuous flow of saline saturated with sulfathiazole is kept dripping into the eye until the acute phase has passed and the edema has largely disappeared. Then the suspension of sulfathiazole in lubricating jelly should be applied every 2 hours while the patient is awake and every 4 hours during the night until cultures are negative. The suspension of sulfathiazole in lubricating jelly should be applied every 4 hours while patient is awake for another week, at which time it may be discontinued. For corneal ulcers and other bacterial infections of the eye, similar treatment may be given, the duration of the continuous drip of sulfathiazole in saline being modified from a few minutes to days according to the seriousness of the infection. For trachoma, a controlled comparison of the treatment with sulfathiazole in suspension in water soluble lubricating jellies should be made with the usual sulfanilamide therapy now employed.

*Ear, nose, and throat lesions* (27) For prophylaxis after operative procedures, sulfathiazole powder is blown from a powder blower on the site of operation immediately on completion. For beta hemolytic streptococcal pharyngitis, sulfathiazole powder is blown on to the inflamed areas at frequent intervals. For acute maxillary sinusitis, a blood level of 5 to 8 milligrams per 100 cubic centimeters is maintained by oral administration of sulfathiazole, the sinus is punctured, irrigated with saline saturated with the drug, and then filled with 20 per cent suspension of sulfathiazole in lubricating jelly. For chronic maxillary sinusitis, the same therapy should be used, but

the oral administration is not necessary. Several treatments at 3 day intervals may be necessary. For ethmoid, frontal or sphenoid sinusitis, the Proetz displacement technique is used to introduce the sulfathiazole suspension in lubricating jelly into the sinuses. For otitis media which has not responded to oral medication and lancing of the drum, the ear is wiped dry and a small amount of sulfathiazole powder is blown into the ear. After mastoid operations sulfathiazole is continued by mouth for a week after the patient is afebrile; the pus is rinsed out with saline saturated with sulfathiazole after the operation, and the wound is packed with sulfathiazole powder and sutured without drainage. The powder must be on the wound edges before coaptation.

**Dentistry and oral surgery** (18) After tooth extractions, the cavity should be filled with sulfathiazole powder by means of a tube and plunger and the gums should be sutured over it.

**Abdominal surgery** When operations on the large bowel are contemplated sulfathiazole by mouth in doses of 0.05 gram per kilogram divided into 6 doses per day for 3 days prior to operation should be given. Powdered sulfathiazole should be sprinkled on the operative site during and after operation. For general peritonitis, one dose of sodium sulfathiazole intravenously should be given just before operation; the abdominal cavity rinsed out with saline saturated with sulfathiazole keeping suction going at the same time that the saline solution is being used for rinsing so that no large volume of saline collects at one time. The irrigation should be continued until the return is clear. Then 10 to 30 grams of the powder are sprinkled from a salt shaker into the abdominal cavity. The same technique should be used for an abscess in the peritoneal cavity except that manipulations should be confined to the infected area. Sulfathiazole powder should be sprinkled between the layers of the abdominal wall during closure and the incision closed without drainage. The blood levels must be checked, and enough sulfathiazole by mouth or sodium sulfathiazole intravenously should be given to maintain the blood level between 5 and 8 milligrams per 100 cubic centimeters for a week after the patient is afebrile.

**Gynecology and obstetrics** Sulfathiazole powder should be blown or sprinkled between the cut surfaces in perineorrhaphy and episiotomy wounds. For puerperal and postabortal infections, adequate blood levels are attained by oral administration of sulfathiazole or intravenous administration of sodium sulfathiazole. Then very gently by gravity the uterine cavity is irrigated with saline saturated with sulfathiazole until the return flow is clear. Sulfathiazole powder is then introduced into the uterine cavity by means of the tube and plunger technique or with a powder in sutfiator.

**Orthopedic surgery** In acute osteomyelitis with bacteremia neomycinbenzoin as described here and sulfathiazole to maintain a blood level of 5 to 8 milligrams per 100 cubic centimeters are given. After the correct blood levels of these drugs are attained the site of the osteomyelitis should be opened, rinsed with saline and then filled with powdered sulfathiazole. In acute osteomyelitis without bacteremia, neomycinbenzoin need be continued for only 3 days and the sulfathiazole only for a week after the patient is afebrile. In chronic osteomyelitis the same therapy should be used; the neomycinbenzoin and sulfathiazole being continued for 3 days after operation and the sulfathiazole for a week or more after operation. It is important that all dead tissue and the walls of infected sinus tracts be removed before the irrigation and packing with sulfathiazole powder.

#### SUMMARY

Investigations by the marrow culture technique show that in equal concentrations sulfathiazole is more effective than sulfapyridine, sulfadiazine or sulfanilamide against any of the common pyogenic organisms, and that sulfanilamide is the least effective of these drugs. In concentrations attained in a saturated solution in a medium similar to tissue fluid sulfathiazole and sulfanilamide are superior to sulfapyridine and sulfadiazine and sulfathiazole is much less toxic to living human cells in this concentration than is sulfanilamide. None of these drugs is very effective against large numbers of organisms in any concentration attainable. Procaine hydro-

oxide and para-aminobenzoic acid inhibit the action of the sulfonamide drugs. Based on these observations certain principles seem practical. Local therapy for prophylaxis is indicated whenever there is a break in continuity of the skin or mucous membrane in a minimally infected or potentially infected area. Local therapy for the control of infection is indicated whenever there is a large number of pathogenic organisms present at one site. Of the drugs now available for local therapy, powdered sulfathiazole seems to be the drug of choice, since it is more effective than sulpyridine or sulfadiazine and less toxic to cells at the concentrations attained than is sulfanilamide. Administration of sulfathiazole, procaine phenamine, or sulfadiazine to maintain adequate blood levels before operation eliminates the old contraindication to early operation, namely, the dissemination of small numbers of organisms into the blood stream or into adjacent tissues. Surgical drainage and rinsing with a saturated solution of sulfathiazole in physiological saline temporarily reduces the number of organisms so that local application of sulfathiazole powder may prove effective. It insures that the full saturated concentration of sulfathiazole will be present at the moment of application. Enough of the powdered drug should be applied to maintain the saturated concentration for at least 72 hours. Local infiltration anesthesia should be avoided, since procaine hydrochloride and probably other local anesthetics inhibit the action of sulfathiazole. Preparations and apparatus needed for this therapy are described, and a number of illustrations of their use are given. For application to mucous membranes and for areas in which the powdered drug is too drying, the water soluble lubricating jellies make a satisfactory suspension medium, since the drug does not settle out, the mixture can be ejected through a fine needle, and it does not stick to dressings or impede drainage. Sodium sulfathiazole should not be used locally, since it has no advantages over sulfathiazole powder used as described and it is so alkaline

that it is likely to produce extensive tissue damage.

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# STUDIES OF CEREBRAL OXYGEN CONSUMPTION FOLLOWING EXPERIMENTAL HEAD INJURY

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IT is generally assumed that many of the reversible signs and symptoms of brain injury which follow trauma to the head, are a result of impaired blood flow to the brain or of oxygen deficiency in the blood supplying the brain or both. Treatment of head injury by intravenous injection of hypertonic fluids, by spinal drainage, or by oxygen therapy is believed to correct one or both of these factors. Impaired blood flow or stasis has never been demonstrated following head injury but is assumed to occur with a rise in intracranial pressure or with brain edema, in accordance with the Munro-Kellie concept of the cranium as a closed box. Such an assumption must be made with reservation if we consider certain limitations of concept.

We believe that stasis and decreased arterial oxygen are rather specious explanations for the pathological physiology of cerebral trauma. In early experiments we came to the conclusion that some more fundamental factor of disturbed physiology was responsible for the syndrome of head injury and considered the possibility that the injured nerve cells might be unable to utilize oxygen normally in spite of an adequate oxygen supply. Some of the reasons for such a consideration are: (1) Symptoms of brain injury begin simultaneously with the trauma, before stasis or decreased blood oxygen can be thoroughly established. (2) The state of consciousness and other symptoms may show improvement while the stasis or oxygen content factors are developing. This is paradoxical if stasis and blood oxygen content are the sole pathological mechanisms involved. (3) We found in a number of experiments that immediately after head injury the oxygen content of venous blood from the brain was increased. This phenomenon cannot be explained on the basis of a reduced arterial oxygen or by stasis in

either of which event the reverse should be true. (4) While it is true that decreased oxygen saturation of arterial blood has been demonstrated following head injury this does not necessarily mean that cerebral oxygen consumption is decreased. The reduced arterial oxygen could be a manifestation of respiratory depression or an altered general metabolic state. Lennox and Gibbs state that within certain limits the oxygen consumption of tissues is unaltered by changes in the oxygen tension of the blood. Furthermore with a constant arterial oxygen during the course of an experiment, any change in the venous oxygen content of blood from a given tissue means either a change in the rate of blood flow through the tissue or an alteration in oxygen consumption by that tissue.

Because of the foregoing objections to the current concepts regarding the pathological physiology of head injury this study of oxygen consumption by the brain in dogs before and after head injury was undertaken. Simple oxygen determinations of arterial and venous blood samples would not measure the net change in cerebral oxygen consumption, nor would measurement of cerebral blood flow alone answer the problem in the presence of so many other variables. Therefore it was necessary to record the blood flow to the brain simultaneously with the removal of both arterial and venous blood samples which were then analyzed for oxygen. These two factors namely cerebral blood flow and arterio-venous oxygen difference (A-V difference) of brain blood enabled us to calculate cerebral oxygen consumption with reasonable accuracy.

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are aware of the assumption in the dog cerebral circulation which makes it impossible to determine exactly how much of the arterial oxygenated blood reaches the brain, but believe that our calculations and the values are approximately correct and valid for the purpose of these studies. There are two concerns with changes in cerebral oxygen consumption. The first is the possibility that the values are not comparable with those recorded in the literature.

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## METHODS

*A Preparation of animals* Large dogs lightly anesthetized with nembutal were used in all experiments. The external carotid artery was ligated on the right side and a sterilized Rein thermostromuhr was applied to the common carotid artery just below the bifurcation. All branches of the carotid that were in the operative field other than the internal carotid were ligated. Care was taken not to disturb the carotid sinus nerves. On the left side the internal carotid was ligated. Thus most of the blood reaching the brain would pass through the thermostromuhr on the right carotid (Fig 1). The vertebral vessels were not disturbed, and some blood would reach the brain through the vertebral arteries.

The internal jugular vein in the dog being of small size and unsuitable for repeated venipuncture, the external jugular vein was prepared for the easy withdrawal of blood samples. We previously determined by injection of the veins and cerebral sinuses that the external jugular in the dog drains a large part of the blood from the brain. Although the venous blood was not exclusively from the brain, we believe it is fair to assume that in this experiment changes in venous blood oxygen were more representative of changes in the brain than of possible changes in other structures of the head. The head was struck after closure of the wounds in the neck if the late effects of head injury were to be studied. If the immediate effects of injury were to be studied the animal was permitted to recover from the operative procedure before the head was injured.

Various methods of injuring the head were tried. The skulls of large dogs are extremely resistant to fracture, and severe trauma to the head is required to produce a gross brain lesion. The criterion of brain injury was a marked inhibition of respiration or apnea for a variable length of time. At the conclusion of the experiments the heads were examined, and many of the skulls were found to be fractured. The brains showed varying degrees of contusion and laceration.

*B Determination of oxygen consumption* Both femoral arteries were exposed and one was connected to a mercury manometer for

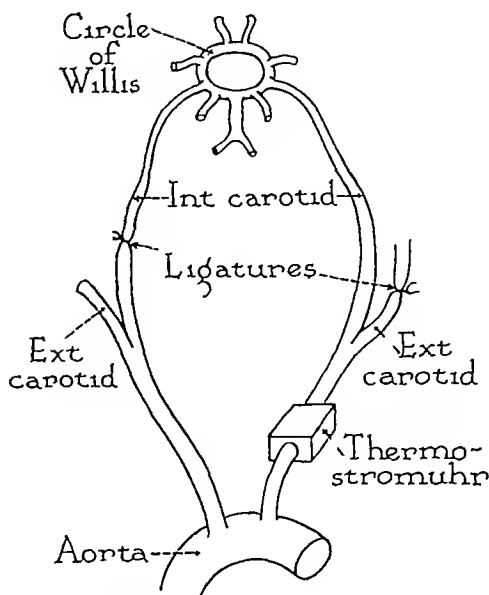
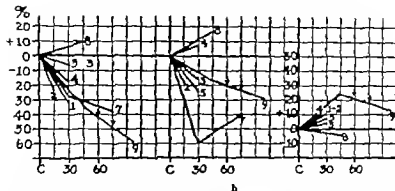


Fig 1 Diagram of operative procedure for preparation of animals

recording blood pressure. The other artery was used for obtaining arterial blood samples. The thermostromuhr on the carotid artery was connected to a galvanometer. When the blood flow stabilized, simultaneous control samples of blood were withdrawn under mercury from the jugular vein and femoral artery. All blood samples were analyzed for oxygen in duplicate with the Van Slyke-Neill manometric apparatus. The blood flow was recorded continuously and further blood samples were taken for purpose of comparison at 15 to 80 minute intervals for a period of from 60 to 80 minutes.

In some experiments two 20 cubic centimeter doses of 50 per cent glucose or sucrose solution were injected intravenously 15 minutes apart after control samples of blood had been obtained, and the experiments were then carried on in the same manner. In others, cisternal drainage was done and its effect on blood flow and A-V difference was observed. In two experiments 100 per cent oxygen was administered to animals suffering from 24 hour old head injuries. Control studies of the cerebral blood flow and of the A-V difference without any other treatment were carried out.



Graph 10. The immediate effect of head injury on cranial blood flow and oxygen consumption, and on the systolic blood pressure. The ordinates represent per cent change from the control value. The abscissas represent time in minutes. Each line is separate experiment. a, Shows change in cranial blood flow; b, change in oxygen consumption; c, change in systolic blood pressure.

#### DESCRIPTION OF RESULTS

Four series of experiments measuring cranial blood flow and oxygen consumption were performed: (1) The immediate effect of head injury on the blood flow and oxygen consumption of the brain; (2) the later effect (after 24 hours); (3) the effect of administration of hypertonic sugar solutions 24 hours after injury; (4) the effect of draining cerebrospinal fluid from the cisterna magna 24 hours after injury. Observations were made of blood flow, arterial and venous oxygen content, arterial oxygen saturation, and arterial blood pressure. To facilitate a comparison of results

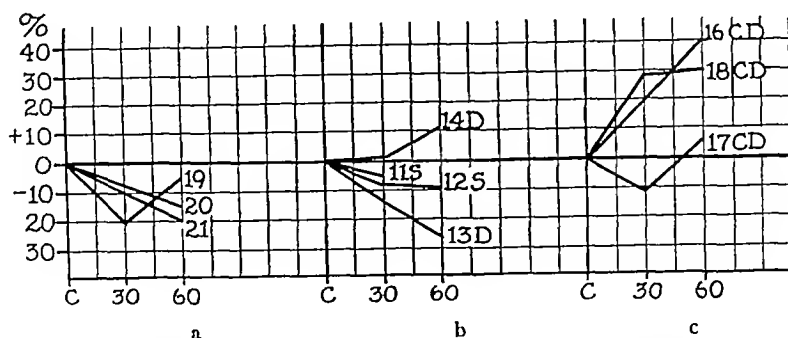
all data are calculated in cubic centimeter per kilogram of dog per minute. In the graphs the variations in the values are presented in per cent of the initial control values of each experiment.

1. Immediately after head injury there is a steady and fairly consistent decline in cranial blood flow and cranial oxygen consumption (Graphs 1a and 1b respectively). There is a fairly consistent increase of systolic blood pressure (Graph 1c). The average decrease in cranial blood flow in 8 experiments was 17 per cent and the average decrease in cranial oxygen consumption was 24 per cent. The actual data are summarized in Table II. The individual values for cranial blood flow in this table vary from 4.1 to 10.0 cubic centimeters per kilogram per minute before injury and from 3.2 to 7.3 cubic centimeters per kilogram per minute after injury. The average values (Table I) are 6.73 and 5.55 cubic centimeters per kilogram per minute respectively. The values for cranial oxygen consumption before injury were 0.10 to 0.50 cubic centimeters per kilogram per minute while after injury they decreased to 0.06 to 0.31 cubic centimeters per kilogram per minute. The average values were 0.160 before and 0.193 cubic centimeters per kilogram per minute after injury.

2. Twenty-four hours after head injury the values for cranial blood flow and oxygen consumption are similar to those obtained immediately after injury. In a group of 10 dogs the

TABLE I.—SUMMARY OF DATA

Experiment	Number of dogs	Cranial blood flow		Cranial O <sub>2</sub> consumption	
		Ar/Avg	Per cent	c./Ar./Avg	Per cent
Control				100	
After injury— immediate			-17	84.3	-24
After injury— 24-48 hrs.	10	24	-29	80.7	-21
Late injury— therapy Hypertonic sugar Control After drug		25 26	-5	8.23	+48
Late injury— therapy Control After drug		30	+15	105 82	+25
Late injury— Time control After injury		30 29	-1	0.200 170	+0



Graph 2 a, The effect of head injury on cranial blood flow after 24 hours, controls  
b, The effect of hypertonic dextrose, D, and sucrose, S, on cranial blood flow 24 hours after injury c, The effect of cisternal drainage on cranial blood flow 24 hours after injury

average change in cranial blood flow was minus 19 per cent of the control series (Table I). The cranial oxygen consumption was minus 21 per cent of the control value. The actual values of cranial blood flow for this group (Table II) ranged from 2.8 to 7.8 cubic centimeters per kilogram per minute, with an average of 5.44 cubic centimeters per kilogram per minute. For cranial oxygen consumption the range was 0.06 to 0.32 with an average value of 0.207 cubic centimeters per kilogram per minute.

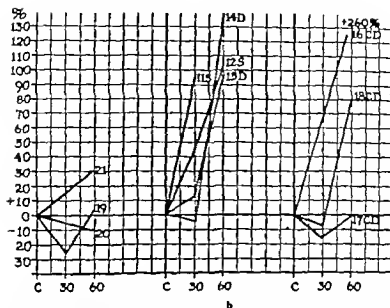
3 Hypertonic sugar solutions were given intravenously to 4 of the dogs studied 24 hours after head injury. One-half to one hour after administration of these agents the cranial blood flow had decreased by 3 per cent, an insignificant amount, but the cranial oxygen consumption had increased 45, 90, 100, and 130 per cent, respectively. Changes in systolic blood pressure (Table III) were inconsequential. The solutions used, 50 per cent glucose and 50 per cent sucrose, produced similar effects (Graphs 2b and 3b). Table I shows that the average oxygen consumption after hypertonic sugar solutions was greater than the control values.

4 Drainage of cerebrospinal fluid from the cisterna magna was performed in 3 dogs 24 hours after head injury. The amount removed varied from 2 to 6 cubic centimeters. The effect of this procedure during an hour of observation is shown in Graphs 2c and 3c. An increase of cranial blood flow averaging 25 per cent was found. The increase in oxygen con-

TABLE II — ACTUAL DATA

Experiment	Dog no	Cranial blood flow c.c./kg/min	Cranial O <sub>2</sub> consumption c.c./kg/min
Before injury	2	7.3	0.28
After injury	2	5.8	0.22
Before injury	3	6.7	0.20
After injury	3	6.8	0.17
Before injury	4	5.6	0.28
After injury	4	5.0	0.31
Before injury	5	7.7	0.16
After injury	5	7.3	0.12
Before injury	6	8.3	
Before injury	7	5.3	0.26
After injury	7	5.8	0.29
Before injury	8	4.1	0.10
After injury	8	2.2	0.06
Before injury	9	10.0	0.29
After injury	9	4.2	0.18
Before injury	10	5.6	0.50
After injury	10	7.3	
24 hours after injury	11	2.8	0.07
After 50% sucrose	11	2.6	0.14
24 hours after injury	12	6.5	0.26
After 50% sucrose	12	6.1	0.37
24 hours after injury	13	6.2	0.32
After 50% dextrose	13	4.6	0.61
24 hours after injury	14	7.1	0.25
After 50% dextrose	14	7.9	0.58
24 hours after injury	16	6.3	0.13
After cistern drainage	16	8.8	0.51
24 hours after injury	17	5.0	0.12
After cistern drainage	17	5.3	0.12
24 hours after injury	18	2.2	0.06
After cistern drainage	18	2.8	0.11
Controls			
24 hours after injury	19	7.8	0.66
One hour later	19	7.6	0.71
24 hours after injury	20	5.6	0.09
One hour later	20	4.8	0.09
24 hours after injury	21	4.9	0.11
One hour later	21	3.9	0.14





Graph 3. a, The effect of head injury on cranial oxygen consumption after 24 hours, controls. b, The effect of hypertonic sugar solutions on cranial oxygen consumption 24 hours after injury. c, The effect of cisternal drainage on cranial oxygen consumption 24 hours after injury.

sumption after cisternal drainage averaged 139 per cent. The effect of cisternal drainage on systolic blood pressure was to lower it (Table III).

TABLE III.—ACTION OF HYPERTONIC SUGAR SOLUTIONS AND CISTERNAL DRAINAGE ON THE SYSTOLIC BLOOD PRESSURE, 24 HOURS AFTER INJURY

Type of experimental	Dog no.	Systolic blood pressure		
		Control	30 min.	60 min.
Control		100		
Control	20	105	105	91
Control	20	90		90
Control	21	115		100
Sucrose		110	90	
Sucrose		110	90	110
Dextrose		115	110	110
Dextrose	11	115	90	90
Cisternal drainage	19	90	90	90
Cisternal drainage		70	90	90
Cisternal drainage	13	100	100	
Cisternal drainage	20	80	100	

Least there be a question that the changes noted in the dogs studied 24 hours after injury could be due to nembutal anesthesia, three control animals were observed. These dogs had received head injuries 24 hours earlier and were studied for the same length of time as were the treated dogs. In these control animals (Graphs 2a and 3a) the blood flow declined 11 per cent and cranial oxygen consumption increased 6 per cent (Table I). The variations in oxygen consumption in the treated animals was vastly greater than this value. Little change was observed in the systolic blood pressure of the controls (Table III).

A reduction of oxygen saturation of arterial blood was regularly observed 24 hours after head injury. The values of oxygen saturation varied from 91 per cent to 73 per cent (Table IV) and are significantly lower than the values for oxygen saturation found in dogs lightly anesthetized with nembutal. This confirms the findings of Schneider and associates. In a few instances the total oxygen consumption of the animal per minute was studied. This value was not changed in animals suffering from immediate or late head injury. The adminis-

TABLE IV — OXYGEN SATURATION OF ARTERIAL BLOOD 24 HOURS AFTER HEAD INJURY

Experiment	Oxygen content Volumes per cent	Oxygen capacity Volumes per cent	Saturation per cent
14	19.7	5.1	78
16	23.8	6.1	91
17	22.7	24.1	59
18	17.0	20.6	84
19	16.0	19.0	81
20	17.0	23.3	73
21	15.0	10.7	76

tration of 100 per cent oxygen to two animals during the course of the experiment caused no appreciable change in cerebral oxygen consumption compared to control values

#### ANALYSIS OF STUDY

The pathological physiology of cerebral trauma cannot be entirely explained either by vascular stasis due to increased intracranial pressure or by decreased arterial oxygen saturation. The concept that symptoms of brain injury are due to stasis of cerebral flow resulting from increased intracranial pressure or increased brain bulk rests upon the so called Munro-Kellie doctrine. This implies that cerebral circulation depends on the hydrostatics of a closed box and on the systemic blood pressure. While this is essentially true, Wolff<sup>1</sup> and others have shown that the cerebral vessels are not passive channels for blood flow. Vasomotor phenomena among other things play a definite rôle in cerebral circulation. Because of the rapid decline in cerebral blood flow following head injury associated with a rise in blood pressure, we believe that vasomotor mechanisms are of much more importance in the early symptoms of head injury than brain edema or increased intracranial pressure. Furthermore, within certain limits there is no apparent quantitative relationship between the amount of blood flowing to the brain and the severity of symptoms of brain injury. In regard to the rôle of available oxygen, we were unable to demonstrate that ordinary changes

in arterial oxygen saturation affect brain oxygen consumption. We are forced to the conclusion, therefore, that symptoms of brain injury are not solely a result of circulatory changes, but that the nerve cells themselves are so affected by injury that they function inadequately. This is borne out by the finding of a decreased cerebral oxygen consumption immediately following injury.

#### CONCLUSIONS

1 Within an hour after trauma sufficient to cause contusion of the brain in dogs, there was an average decrease of 24 per cent in cerebral oxygen consumption, and of 17 per cent in cerebral blood flow. The following day there was but little change in these values.

2 The administration of 50 per cent glucose or sucrose to dogs with a 24 hour old head injury was followed within an hour by a striking increase in brain oxygen consumption but no significant change was noted in cranial blood flow.

3 Drainage of cerebrospinal fluid in dogs with 24 hour old head injuries was followed by an even greater increase in brain oxygen consumption and by a 25 per cent increase in cranial blood flow.

4 The administration of 100 per cent oxygen to 2 animals during the course of the experiment caused no appreciable change in cerebral oxygen consumption, compared to control values.

5 These experiments indicate that the impaired cerebral blood flow following head injury is affected relatively little by therapy, whereas cerebral oxygen consumption is strikingly increased. The oxygen consumption of the brain is not dependent on blood flow alone or on arterial oxygen alone. We believe that the metabolism of the nerve tissues and their ability to use oxygen is directly affected by head injury. Such a mechanism could explain the phenomenon of concussion.

6 Since hypertonic solutions and spinal fluid drainage increase brain oxygen consumption, there is a rational basis for their use for this purpose.

<sup>1</sup> Wolff H. G. *Physiol. Rev.* 1936 16 545

# LOCAL SULFANILAMIDE IN COMPOUND FRACTURES

## An Experimental and Clinical Evaluation

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EARLY in 1938 we initiated an experimental and clinical study of the feasibility of implanting sulfanilamide powder in compound fractures. Prior to this, Brown in England and Jaeger, Tilling and Merz in Germany, had reported the local use of prontosil soluble (neoprontosil) in the treatment of a few cases of established infections, but no one had reported either an experimental or clinical study of the prophylactic value of sulfanilamide in the treatment of contaminated wounds.

A preliminary report on this study was submitted for publication in February of 1939. The present paper for the sake of completeness, includes most of the experimental and clinical data from this earlier publication. In addition we are reporting all of the compound fractures treated up to December 1 of 1941.

From December of 1937 to July of 1939 the treatment of these fractures was carried out by Dr. Johanson or one of us. Since then the actual treatment has been by Drs. Freedman, Welte, Moos or Farkas, fracture residents for the successive semiannual periods. Occasional patients have also been treated by members of the visiting staff. This has unavoidably resulted in some variation in treatment particularly as each of these men started their fracture residencies as relatively inexperienced surgeons. Every effort was made by these men however to follow the basic fundamentals of the program which we had initiated. Furthermore from the beginning this work has been carried out under the supervision of Dr. A. A. Zierold, professor of surgery at the University of Minnesota, and chief of the surgical service at the Minneapolis General Hospital. This constant change in operative

personnel adequately eliminates the personal factor from the clinical studies. However a skilled surgeon personally handling this number of consecutive cases would have avoided some of the recurrent errors which were made in this series.

### EXPERIMENTAL STUDIES

In our earlier report we showed that sulfanilamide powder buried in a wound gradually finds its way into the general circulation, reaching a maximum level in the blood at the end of about 18 hours and finally disappearing in about 60 hours. Marshall's studies have shown that after a single large dose by mouth practically all the drug is eliminated in 24 hours. This would indicate that absorption continues from a wound for over 30 hours. During this time actual measurements (11) in man have shown that the serum, hematoma, and local tissues of the wound are saturated with sulfanilamide at approximately 0.8 per cent concentration; the solubility of this compound at body temperature.

Hawking has subsequently studied the absorption of solid sulfanilamide from wounds of guinea pigs and rabbits and found that high local concentrations persist for 24 hours. However it is probable that the drug is absorbed faster from the wounds of small animals due to the fact that their metabolic rate is higher.

These observations indicate that locally implanted sulfanilamide gives a concentration in the area of contamination 80 times that obtainable by systemic administration. Since the bacterostatic and bactericidal power of sulfanilamide is a function of its concentration, other things being equal it is logical to assume that local implantation will be more effective in the prevention of infection of contaminated wounds than will a systemic administration.

From the Minneapolis General Hospital and the Department of Surgery of the University of Minnesota.  
Dr. Jensen is now on active duty as Major in the Medical Corps of the U. S. Army.

TABLE I—COMPOUND FRACTURES OF RIB—WOUNDS CONTAMINATED WITH FRESHLY ISOLATED (24 HOURS) CULTURE OF STAPHYLOCOCCUS AUREUS HEMOLYTICUS, 0.5 GRAM SULFANILAMIDE POWDER IMPLANTED

Local sulfanilamide		Systemic sulfanilamide		Control	
No *	Result	No	Result	No	Result
17	Infected 8th day <sup>f</sup>	22	Died 4th day (autopsy) <sup>g</sup>	1	Wound draining 4th day
18	Infected 8th day <sup>†</sup>	23	Died 8th day (autopsy) <sup>g</sup>	2	Wound draining 6th day
16	Sacrificed 3rd day <sup>‡</sup>	27	Wound draining 4th day	3	Wound draining 7th day
7	Healed <i>per primam</i>	13	Wound draining 4th day	11	Wound draining 8th day
6	Healed <i>per primam</i>	19	Wound draining 6th day	9	Sacrificed 3rd day <sup>11</sup>
5	Healed <i>per primam</i>	25	Wound draining 6th day	8	Healed <i>per primam</i>
15	Healed <i>per primam</i>	26	Wound draining 6th day	10	Healed <i>per primam</i>
14	Healed <i>per primam</i>	20	Wound draining 6th day		
12	Healed <i>per primam</i>	21	Healed <i>per primam</i>		
4	Healed <i>per primam</i>	24	Healed <i>per primam</i>		
20% Infection No deaths		80% Infection 20% Mortality		71.4% Infection No deaths	

\*No refers to identification number of animals

<sup>f</sup>Wound left gaping allowing drug to drain away with serum result infection

<sup>†</sup>Subjected to 3 cardiac punctures in 3 days removing a total of 10 c.c.

<sup>‡</sup>Autopsy of pigs with systemic sulfanilamide showed acute pleurisy, severe wound infection and wound and heart blood cultures showed Staphylococcus aureus hemolyticus

<sup>§</sup>Autopsy of pig sacrificed after 3 days with local sulfanilamide revealed clean healing wound and no evidence of metastatic spread Culture from wound revealed Staphylococcus aureus hemolyticus from heart's blood negative

<sup>11</sup>Autopsy of control animals at 3 days revealed severe wound infection acute pleurisy bronchopneumonia Culture of wound and heart's blood revealed Staphylococcus aureus hemolyticus

The following experiments were designed to test the validity of this assumption and define the factors present in traumatic wounds which might lead to infection even in the presence of sulfanilamide. The guinea pigs selected for these studies were of uniform size and age and all were free from previous pyogenic infection. A standard wound was produced under ether anesthesia by incising the pectoral muscles of the guinea pigs and fracturing a rib on one side. This fracture was adopted because here the motion of the fragments would be uniform from animal to animal, being determined by their respiration. In those instances in which the pleura was opened the animals were discarded. Closure was by fine silk or cotton suture to the skin only. When sulfanilamide powder was inserted, it was spread uniformly throughout the wound prior to closure. The culture used in experiment I was a Staphylococcus aureus hemolyticus freshly isolated from the blood of a youth dying of Staphylococcal septicemia. In the subsequent experiments we used a lyophilized Staphylococcus aureus hemolyticus, coagulase positive, supplied us by Dr George A. Hunt. These organisms were prepared for inoculation by

culturing 24 hours in peptone broth, then freed of the broth by repeated centrifugation and resuspension in sterile normal saline. The number of the organisms was then calculated by centrifugation of an aliquot in a Hopkins tube which had been calibrated by plate counts for this particular organism.

Thus by obtaining a strain of Staphylococcus aureus of assured standard virulence and by using this organism in known number as an inoculum in standard wounds in uniform nonimmune animals, the factors resulting in infection could be assayed. The questions to be answered were (1) Is local sulfanilamide more effective prophylactically than systemically administered sulfanilamide? (2) How does the number of organisms originally inoculated in the wound influence the outcome? (3) What is the effect of foreign particulate matter in the wound? (4) What is the effect of macerated dying tissue in the wound?

#### DISCUSSION OF EXPERIMENTAL STUDIES

*Experiment I* The comparison between local and systemically administered sulfanilamide (Table I) shows that local sulfanilamide protects against staphylococcal infection in a

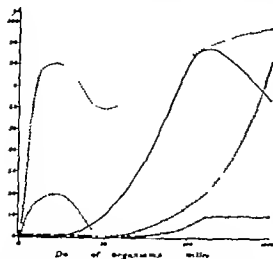


Fig. 1. Graphic expression of results in experiment II. controls; — local sulfanilamide infection; ..... local sulfanilamide deaths.

TABLE II.—PROGRESSIVE FAILURE OF LOCAL SULFANILAMIDE AS SIZE OF DOSE OF CONTAMINATING ORGANISMS IS INCREASED

Dose of organisms	No. of animals	Survival			
		Control		2% local sulfanilamide	
In millions	Total %	Infection	Deaths	Infection	Deaths
1	10	100%	100%	100%	100%
2	10	100%	100%	100%	100%
50	10	100%	100%	100%	100%
100	10	100%	100%	100%	100%
1000	10	100%	100%	100%	100%

Most culture seed (staphylococcus aureus hemolytic). Standard compound fracture of rib produced as described.

\*No. of animals refers to the number used in each experiment in one trial and in limited animals. Total number necessarily about 100. This means that data were not completely satisfactory. Favorable results from the point of organism count were in liver and lungs were found in addition to lower small intestine and kidneys were found with hemolytic streptococci. Culture of bone marrow and heart's blood revealed staphylococcus aureus hemolytic.

with an overwhelming dose local sulfanilamide will protect many of the animals against fatal sepsis as the mortality rate is much less in the treated animals than in the controls (Fig. 1).

*In vivo* studies show this same phenomenon. Many workers have observed with all the sulfonamides that if the inoculum be too great no bacteriostasis is demonstrable. The clinical application of this fact is obvious. Débridement of contaminated wounds must be carried out meticulously enough so as to reduce materially the number of contaminating organisms.

*Experiment 3.* King and Henschel's studies beautifully demonstrate *in vivo* the inhibition of sulfanilamide by autolyzing tissue. These workers found that a tiny fragment of dying muscle liver or brain in a Madsen tissue culture containing sulfanilamide allowed colonies to develop in its immediate vicinity whereas bacteriostasis was excellent in all other parts of the culture. Figures 2, 3, and 4 show this very well.

Table III shows the effect of a fragment of macerated muscle in wounds. It is evident that local sulfanilamide is not of much value in the presence of dying tissue. Clinically this means that a débridement must be thorough enough to excise all macerated and devitalized tissue if local implantation of sulfanilamide is to be of any benefit. Furthermore, whatever

high proportion of animals—80 per cent—whereas the same amount systemically administered fails almost completely—80 per cent infected, 50 per cent died. Stimulated by the preliminary report of our work (11) Nitti in France, carried out similar experiments in rabbits using beta hemolytic streptococci. His studies likewise revealed that local sulfanilamide implanted at the time of contamination of the wound was very effective. More recently Hawking found that local sulfathiazole protected 58 per cent of animals inoculated with *Clostridium welchii* and *Clostridium septicum* whereas systemic administration of the same amount of drug even 2 hours previously saved only 23 per cent of the animals.

*Experiment 2.* The most obvious factor conditioning the development of infection in any wound is the number and virulence of the organisms contaminating the wound. The studies reported in Table II and Figure 1 show that sulfanilamide locally implanted does not alter this consideration. The presence of local sulfanilamide will allow a wound to heal *per primam* with a much larger initial contamination than is otherwise possible. However if the dose of organisms be great, sulfanilamide will not prevent the development of local suppuration. It appears, however that even

TABLE III —FAILURE OF LOCALLY IMPLANTED SULFANILAMIDE IN THE PRESENCE OF MACERATED MUSCLE

No of animals	Sulfanilamide	Macerated muscle	Infection	Death
8	0.25 gm	No	None	None
8	0.25 gm	Yes	8 (100%)	1* (12.5%) (5 days)
2	None	No	2 (100%)	None
2	None	Yes	2 (100%)	1* (50%) (7 days)

Standard compound fracture of rib produced, contaminated with culture of staphylococcus aureus hemolyticus (coagulase positive) and streptococcus hemolyticus freshly isolated from wound of guinea pig dying of this infection, macerated muscle fragment (3 by 3 by 2 mm) left in wounds as indicated

\*Autopsy of the two guinea pigs that died showed multiple metastatic abscesses in liver and spleen

closure is attempted must avoid strangulation of tissue, and buried absorbable suture material should be avoided. Immobilization must be complete to prevent further damage to soft parts which might be caused by motion of the bony fragments

*Experiment 4* Local sulfanilamide appears to be of limited value in the presence of foreign material in the wound.<sup>1</sup> In the experiments reported here, Table IV, the animals with charcoal and sulfanilamide in their wounds did a little better than those with charcoal and no sulfanilamide. The animals without either did much better, while those with no foreign material and sulfanilamide healed *per primam*. Nitti's studies show that implantation of a piece of fabric saturated with a culture of virulent hemolytic streptococci quickly kills an unprotected rabbit. Implantation of sulfanilamide at the same time appears to protect the animals against fatal sepsis for a time. If the wound is reopened in 48 hours, the fabric removed, débridement accomplished, and sulfanilamide again implanted, most of the animals live. When death occurs, it is delayed for an interval of 8 or 10 days. The experiments of Legroux and Hawking also show this same effect of locally implanted sulfanilamide.

Here again the clinical implication is that débridement must be thorough enough to remove all foreign material and soiled tissue if

<sup>1</sup> Vitalium seems to be an exception—see Clinical Discussion Fig 7

TABLE IV —EFFECT OF FOREIGN MATERIAL IN CONTAMINATED WOUNDS TREATED WITH LOCAL SULFANILAMIDE IMPLANTATION

No of animals	Sulfanilamide	Charcoal	Infection	Death
3	0.25 gm	0	None	None
3	0	0	3 (100%)	None
3	0.25 gm	0.050 gm	3 (100%)	2 (66.6%)
3	0	0.050 gm	3 (100%)	3 (100%)

Standard compound fracture as previously described, contaminated with 5 million organisms (Hunt strain of staphylococcus aureus). Guinea pigs used. Charcoal sterilized by autoclave (250° C for 20 minutes)

the implantation of sulfanilamide is to be of great benefit in promoting healing without suppuration. However, it may be that in the presence of foreign material retained unduly long, as in Nitti's experiments, local sulfanilamide will prevent the development of fatal sepsis, and delayed débridement can be carried out with reimplantation of the drug at this time.

*Experiment 5* For the studies on gas gangrene a mixed culture was selected because the cases seen at the Minneapolis General Hospital have almost invariably resulted from such a mixture of one or more of the Clostridia with hemolytic streptococci. Clinically, it has been our observation that this type of gas infection does not necessarily depend for its development on devitalized muscle or imbedded foreign material. The invasive virulent streptococci produce all the tissue devitalization required by the anaerobes. Débridement alone will not obviate these infections as we saw them prior to our use of sulfanilamide following careful meticulous débridement of compound fractures, following elective amputations where the only damage to muscle was that which was produced by a sharp amputation knife, and even following guillotine amputations.

Table V shows that local sulfanilamide will prevent infection in wounds inoculated with a lethal mixture of streptococci, staphylococci, and Clostridium welchii. The recent study of Hawking in England throws additional light on this subject. He found that sulfanilamide used locally protected 53 per cent of his animals against a fatal dose of Clostridium

TABLE 1.—PROPHYLAXIS OF GAS GANGRENE INFECTION BY LOCAL IMPLANTATION OF SULFANTAMIDE

No therapy		Local sulfanilamide 25 gm	
Animal	Result	Animal	Result
	Sacrificed 7th day		Finished pre pneumonia
	Died 8th day		Pyogenic wound healed
	Severe gas infection—respiratory		Finished pre pneumonia
	Died 2nd day		Healed pre pneumonia
3	Died 6th day		Sacrificed 7th day?

Gas pneumonia 100% Mortality 100%

No gas pneumonia No death

Wounds produced by clean incision through pectoral muscles & ribs, no ribs cut, no effort made to evacuate muscle, wounds inoculated with 3 loops of material from gangrenous wound of guinea pig, dying 7 hours after inoculation. Its mixture of *Clostridium*, *Escherichia*, *Staphylococcus aureus*, *Bacteroides*, coagulase positive and beta *Streptococcus hemolyticus*. Culture of this material as used for inoculation in this experiment revealed these same organisms. This culture, as originally recovered from clinical case of gas gangrene following a localized, minimal compound fracture of forearm (not treated by us).

sacrificed just before death for liberal culture. This was positive for all three organisms mentioned, as was sexual culture. Autopsy showed extensive pneumonic destruction with much gas of almost all the muscles of right side of chest and upper abdomen.

†Few drops of pure obtained from wood on 4th day. Culture 12-14-  
bacteria strong anaerobic, catalase positive. Wood heated without  
boiling down by 20 days.

Dissected to compare with infected animals sacrificed on same day (7). Culture of heart blood was sterile, of wound exudate (Papanicolaou) negative. Autopsy showed no abnormalities except little oozing with some pus (2-3 drops) in depth of wound. Skin had healed per se at this time.

welchii in the presence of macerated muscle and foreign material. Legroux somewhat earlier studied the effect of local sulfanilamide. He found that wounds infected by insertion of a piece of cloth soaked in a culture of *Clostridium welchii* or *Clostridium histolyticum* caused death in control animals in 2 to 3 days whereas animals which received local sulfanilamide died after 4 to 7 days, but if the wound were reopened the cloth removed and new sulfanilamide added they survived. Delay of the treatment for more than 1 hour after insertion of the culture or the administration of the drug only by mouth resulted in death of the animals.

Hawking also studied *Clostridium septicum* and *Clostridium oedematiens* infections. He found local sulfanilamide delayed the death of

animals infected with *Clostridium septicum* and protected 28 per cent of the animals against *Clostridium oedematiens*.<sup>1</sup> Sulfathiazole however protected 67 per cent of the animals against *Clostridium septicum* but only 33 per cent against *Clostridium oedematiens*. Sulfapyridine was inferior to both sulfanil amide and sulfathiazole. Serum (antitoxin) both specific monovalent and polyvalent, was found ineffective against some of the strains of *Clostridium welchii* which were studied, against all of the strains of *Clostridium septicum* but worked very well against *Clostridium oedematiens*.

Hawking suggests that sulfathiazole or a mixture of one part sulfathiazole and two parts sulfanilamide be used locally in conjunction with serum to cover the *Clostridium oedematiens* infections. This may come to be the best practice. However it should be pointed out that in the 2:1:2 compound fractures reported in this paper not a single case of gas gangrene has occurred in a fracture when adequate débridement was performed and local sulfanilamide implanted. Polyvalent serum was also given prophylactically to all these patients.

### EFFECT OF TEMPERATURE

*In vitro* studies by many investigators of the bacteriostatic power of sulfanilamide against a variety of organisms have revealed that the activity of the drug is greatly enhanced by temperatures of 37 degrees C and above. While studying the streptococidal activity of this compound reports that at 30 degrees C concentrations of less than 1000 milligrams per cent are inactive at 16 degrees C concentrations of less than 100 milligram per cent are inactive while at 39 degrees C concentrations of less than 10 milligrams per cent are bactericidal. He points out that sulfanilamide is 100 times as active at 30 degrees C as at 37 degrees C. Spink found sulfanilamide to be much more active at 40 degrees C than at 37 degrees C against staphylococci. Netter reports the same obser-

1. per cent of the contents of the water column  
 2. have had cases of gas gangrene dominating composition, other  
 3. implications of sulfonamide. In hot water in composition of  
 4. a sample after amputation of animal and other gross bacteria material  
 5. *Flavobacterium streptococcus*, *Escherichia* per 1 Gram

vations with both hemolytic and nonhemolytic enterococci

These studies suggest that in the prophylactic use of sulfanilamide, the temperature of the wound should be kept at 37 degrees C or above. It may prove worthwhile to use diathermy to raise the local temperature of an extremity during the critical first 24 to 36 hours. In our clinical studies we have unconsciously taken some advantage of this phenomenon.

#### SUMMARY

In summary our experimental investigations and those reported by others suggest

1 Sulfanilamide is more effective when implanted locally than when systemically administered in the prophylaxis of wound infection

2 Local sulfanilamide will not prevent infections in the presence of massive doses of contaminating organisms, although it does appear to lessen the severity of these infections

3 Devitalized tissue will inhibit the activity of locally implanted sulfanilamide

4 Foreign particulate matter will protect the contaminating organisms against sulfanilamide

5 Sulfanilamide locally administered is more effective against *Clostridium welchii* and *Clostridium histolyticum* infections than systemically administered drug. It is of little value against *Clostridium septicum* or *Clostridium oedematiens* with either route of administration. (a) In wounds carefully excised, gas bacillus infections are rare unless invasion and devitalization of the tissue by a virulent aerobic organism occurs (e.g. *Streptococcus hemolyticus*). Local sulfanilamide will protect against this type of infection and consequently greatly reduce the incidence of anaerobic infections. (b) Sulfathiazole locally implanted is effective against *Clostridium septicum* (Hawking). (c) Polyvalent serum (antitoxin) seems to be the most effective agent for *Clostridium oedematiens* (Hawking). (d) Delay of even 1 hour in local implantation of the drug in gas bacilli contaminated wounds materially reduces the effectiveness of sulfonamides (Legroux).

6 The antibacterial action of sulfanilamide is directly proportional to the temperature. It is suggested that means be used to keep the temperature of a wound at 37 degrees C or above during the first 24 to 36 hours.

#### CONCLUSION

Reduction of the dose of contaminating organisms and excision of all devitalized tissue by careful meticulous débridement of compound fractures followed by complete immobilization of the fragments and appropriate steps to maintain the temperature of the wound at 37 degrees C or above will fulfill the requirements for effective local antibacterial action of solid sulfanilamide implanted in these wounds.

#### CLINICAL STUDIES

##### PRELIMINARY CONSIDERATIONS

Any substance that is to be implanted in wounds must fulfill two primary requisites: it must be nontoxic to the local tissues and absorption of the substance must not produce toxicity in the patient.

Our studies (11) of the absorption and excretion of sulfanilamide have shown that 5 to 20 grams can safely be placed in a wound without fear of excessive systemic concentration of the drug.<sup>1</sup> We have found that the blood level will be at its maximum in 18 to 20 hours and in an average size adult with normal renal function the blood level will be in milligrams per cent about the same as the number of grams of drug implanted if the wound be closed primarily (e.g. 10 to 12 milligrams per cent for 10 grams implanted in a compounded tibia). If the wound be left open and covered with vaseline gauze, the level in the blood will be much less, consequently, larger doses can advantageously be used.

In the 212 cases which are reported here we have not seen a single instance of toxicity from the use of the drug other than the usual cyanosis. We have also used it in many other wounds as will be mentioned and have observed no toxicity.

<sup>1</sup>This statement applies only to wounds, not to serous cavities. The drug is probably much more rapidly absorbed from the pleural and peritoneal surfaces and here 5 grams should be the maximum (Richard Varco personal communication).



The second consideration is the effect of the compound on local tissues and healing. Key and Burford have reported an excellent study of this phase of the problem and their conclusions that no significant delay in healing occurs with sulfanilamide is well supported by our clinical experience with the use of the compound in a wide variety of wounds which were cared for at the Minneapolis General Hospital.

For more than 3 years we have implanted sulfanilamide powder in all tendon lacerations which were primarily sutured and in all herniorrhaphies in which fascia transplants were used. With both "split thickness" and "full thickness" skin grafts, it has been our custom to dust the graft bed with a thin layer of sulfanilamide powder before suturing the grafts in place. We then again apply a thin layer of sulfanilamide powder over which a xeroform ointment dressing with sea sponge pressure is applied. The results have been excellent. Tendons heal without infection and failure of union has been infrequent. Our use of large fascial grafts has increased considerably since we found that with sulfanilamide locally implanted the chance of postoperative infection was greatly reduced and firm healing progressed rapidly. Skin grafts which have been dusted with sulfanilamide take as rapidly as do those which have not been so treated, and the occasional loss due to infection has been avoided.

A more critical study of the effect of local sulfonamides on tissue has been made by Russell and Falconer in England. These workers injected suspensions of solid sulfanilamide, soluseptazine, and sulfapyridine into the brain of rabbits. Microscopical preparations made at suitable intervals were then studied. No cellular reaction was found in the case of sulfanilamide or soluseptazine. For eign body reaction occurred about the sulfapyridine crystals which were very slowly absorbed. Hurteau of Canada has studied the effect of implantation of sulfanilamide, sulfapyridine and sulfathiazole into operative incisions in cats' brains. In like manner it was impossible for him to demonstrate any deleterious effects resulting from the use of sulfanilamide.

#### TREATMENT

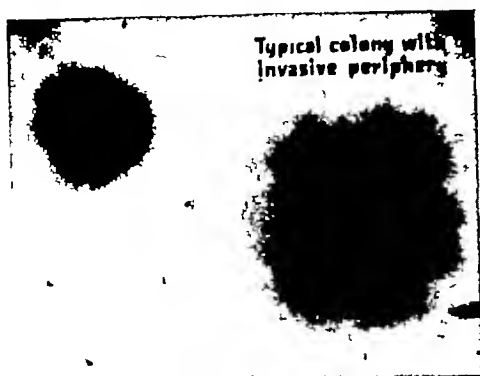
As sulfanilamide is not a panacea it is essential that the conditions under which it has been used in this study be outlined completely.

The compound fractures admitted to the Minneapolis General Hospital have usually resulted from automobile accidents. Our patients are drawn from the very poorest of the city—from the unfortunate undermourished and unwashed side of life. All this results in terribly contaminated fractures with a great deal of soft tissue damage. Many patients sustaining compound fractures exhibit shock on admission to the hospital, and all show evidence of impending shock. Successful treatment of the fracture demands prompt treatment of the shock, and we have found nothing better than control of pain and transfusion of plasma or whole blood if necessary.

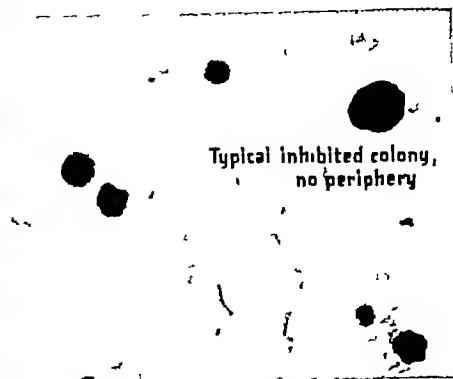
X-ray pictures are obtained in seriously injured patients only after shock treatment has been instituted and usually after the patient has been transported to the operating suite. We are of the opinion that the time consumed for these films is well spent, as they often bring a much better realization of the extent of the injury than does observation alone.

We have avoided local infiltration anesthesia because of the danger of carrying infection into the deeper tissues and because the discovery by Woods that procaine is a very potent sulfonamide inhibitor *in vivo* suggests that the *in vivo* action may be similar. In most instances, regional block such as brachial plexus block for the upper extremity and spinal anesthesia for the lower have been used. If these have been impractical as in children for example general anesthesia has been used. The patient's stomach is pumped before induction of inhalation or intravenous anesthesia and a suction tube is left in the stomach during anesthesia. Food which is present in the stomach at the time of injury will still be there undigested many hours later as trauma and subsequent shock stop all digestion.

After the establishment of anesthesia, proper preparation of the extremity is under



Typical colony with  
invasive periphery



Typical inhibited colony,  
no periphery

Fig 2, left No sulfanilamide Normal colony development. Note invasive periphery

Fig 3 Sulfanilamide Inhibition of colony development. Colonies much smaller and no invasive periphery

taken The wound is covered with a small sterile dressing The entire limb is washed with sterile soap and water, then shaved Next the field is washed with alcohol, followed by ether, and finally is painted with any good skin antiseptic After this preparation, sterile drapes are placed and the gauze dressings over the wound are removed Again, using sterile soap and water and sterile gloves, the area around the wound is washed, care being taken not to wash dirt into the wound A sharp scalpel makes an efficient sterile razor and with this the adjacent skin is shaved and the scalpel is discarded Then this area is painted with antiseptic solution, none being allowed to enter the wound

Using fresh gloves and instruments, and gowning as for a major procedure, the surgeon excises the skin margin and soiled subcutaneous tissues and picks the superficial gross particles from the wound This should be done without contaminating one's gloves, and the instruments used should be discarded Next, the depth of the wound is explored and all soiled and devitalized tissue excised Loose fragments of bone are removed Muscle should be cut back until it twitches when touched with the knife Frayed fascia and periosteum are excised and the soiled ends of the bones are rongeuired away Finally, the wound is carefully irrigated with 5 to 10 quarts of warm normal saline and all waving filaments of tissue removed

Dry sterile drapes are now placed and, with fresh gloves and instruments, the surgeon

again carefully goes over the wound, appraising its viability and cleanliness millimeter by millimeter Dying muscle, fascia, and bone must be removed for they will inactivate sulfanilamide and furnish an excellent culture media

Finally sterile sulfanilamide powder is distributed throughout the wound in sufficient quantity to cover all the surfaces (5 to 20 grams) and the wound is closed without tension by interrupted silk sutures in the skin only Countercutting of the skin and subcutaneous fascia and fat down to the deep fascia well away from the wound will often allow closure without tension (Figure 5) These counterincisions should be placed a

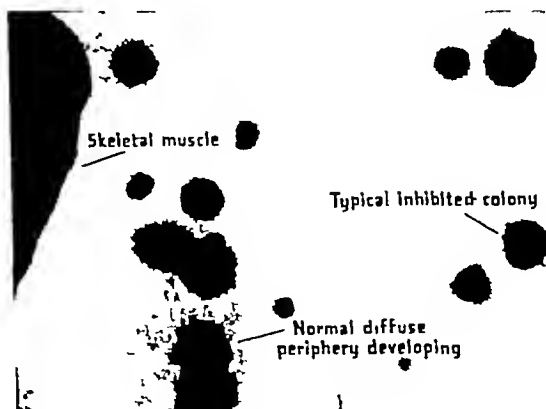


Fig 4 Sulfanilamide—autolyzing muscle Effect of fragment of dying muscle on bacteriostatic power of sulfanilamide Note development of colonies with invasive periphery adjacent to autolyzing muscle while more distant colonies show typical sulfanilamide inhibition



Fig. 5. Photograph of the sacrificed animals of experiment 5 just prior to killing. The black gauze plug is on the edge of death. Note the distention of his neck and chest until it covers his paws. This is due to gross emphysema of the soft tissues. The bite gauze plug is perfectly all. Both animals are the same size before inoculation (litter mates).

quarter of the circumference of the extremity away from the wound and should be in the long axis of the extremity. They are lightly dusted with sulfanilamide powder covered with vaseline gauze and will have healed long before the fracture has united.

If closure cannot be accomplished without tension a larger amount of sulfanilamide powder (20 to 40 grams) is layered over the surfaces of the wound and covered with vaseline gauze.<sup>1</sup> Plaster is then applied directly over this as in the Orr treatment. If doubt exists as to the efficacy of the débridement or the viability of any part, primary suture should not be attempted.

Treatment of the fracture is next undertaken. Skeletal traction with supporting plaster splints to prevent motion at the fracture site is routinely used in fractures of the tibia, femur and humerus. Fractures of the forearm are usually handled in plaster splints alone but occasionally we have used two-pin casts when necessary to accomplish complete stable reduction. We do not undo casts. Wounds are not examined or dressed for 3 to 5 weeks unless the clinical symptoms demand it. In this connection it is well to remember

that even closed fractures are followed by moderate fever for a few days. Increased local pain with evidence of swelling and rapid pulse is suggestive of gas gangrene and demands immediate inspection otherwise dressing or examination of the wound only invites infection.

#### CLINICAL RESULTS

During the years 1932-1937 and the first 3 months of 1938, the treatment of compound fractures at the Minneapolis General Hospital was identical with that outlined above except that sulfanilamide was not used. The visiting staff directing the fracture service was the same in each of these years. For this reason we have selected these years, which incidentally were among the most successful prior to sulfanilamide for comparison with the series treated with sulfanilamide.

A summary of the results which were obtained in these years is given in Tables VI, VII and VIII.

It will be seen that the incidence of infection was 25.8 per cent in 1932, 27.5 per cent in 1937 and 27.2 per cent in the first 3 months of 1938. During these years a total of 96 compound fractures was treated. Twenty-five of these fractures became infected, 7 of them developed gas gangrene and 5 secondary amputations were performed to control infection. Average hospital stay for the entire 96 cases was 96.3 days.

From the last of March of 1938 to the first of December of 1941, 212 compound fractures were treated by the local implantation of sulfanilamide in addition to débridement and immobilization (Table IX). In this group 7 primary and 2 secondary wound infections developed. Two cases of gas gangrene occurred requiring secondary amputation. Both cases resulted from inadequate débridement and irrigation as carried out by inexperienced men. The average hospital stay for this group of patients was 30 days, a reduction of 70 per cent.

Two of these infections occurred from contamination of the wounds. Both patients in the manual stages of delirium tremens recomposed their tibial fractures, one on the 8th day the other on the 7th day after reduction. In both instances we simply re-

<sup>1</sup>In our first case (Surgery, 1936, 6), we closed every wound by sutures of the skin only. In February of 1939, J. J. Berry of St. Louis, Missouri, became interested in this study. He told us of several cases which he had been unable to treat primarily and which he had successfully treated as outlined above. Since then we have adopted this practice in similar cases. The method will be described fully in a publication to appear subsequently.

TABLE VI—COMPOUND FRACTURES TREATED IN 1932

Method of treatment	Tibiae fibulae		Radii ulnae		Phalanges metacarpals		Femora		Humeri	
	No	%	No	%	No	%	No	%	No	%
Primary suture	17	54.8	7	22.6	4	12.9	1	3.2	2	6.5
Open wound	15	88.2	7	100.0	3	75.0	1	100.0	2	100.0
Dakin's	1	5.9			1	25.0				
Cast	1	5.9								
Traction	12	70.6	7	100.0	3	75.0			1	50.0
Amputation to control infection	2	11.8					1	100.0	1	50.0
Traumatic amputation	3	17.6								
Gas gangrene	1	5.9			1	25.0				
Infection	1	5.9								
Infection	4	23.5	1	14.3	1	25.0	1	100.0	1	50.0

Summary 31 open fractures  
8 became infected } Incidence of infection 25.8%

duced the fractures on the ward and applied new plaster splints without any treatment of the wounds. These occurred before we found that clean wounds could be expected if we layered the wound with a thick coat of sulfanilamide powder and loosely packed it with vaseline gauze. We now believe that if we had taken these patients back to the operating room, excised the freshly damaged tissue, then treated them by the open method, we still might have avoided infection. No evidence of infection was present in either case before the recontamination occurred, but promptly after that both patients became febrile and soon pus drained from their wounds.

These 2 cases represent failure in handling the complications of compound fractures. Patients who are showing the prodromes of delirium tremens must be kept adequately sedated, and it is probable that compound tibiae and humeri should always be internally fixed with long, firmly applied vitalium plates at the time of débridement (Fig. 7).

One infection developed under circumstances that duplicated the experiments performed in animals to test the effectiveness of sulfanilamide given systemically or used locally. A patient was admitted with an extensive compound fracture of the upper one-third of the tibia. After completion of a painstaking

TABLE VII—COMPOUND FRACTURES TREATED IN 1937

Method of treatment	Fibulae tibiae		Radii ulnae		Phalanges metacarpals		Femora		Humeri	
	No	%	No	%	No	%	No	%	No	%
Primary suture	21	52.5	7	17.5	5	12.5	3	7.5	4	10
Open wound	17	80.9	6	85.7	4	80.0	2	66.6	3	75
Dakin's	3	14.3	1	14.2	1	20.0	1	33.3	1	25
Cast	1	4.7								
Traction	5	23.8	6	85.7	4	80.0			2	50
Amputation to control infection	12	57.1					2	66.6	2	50
Traumatic amputation			1	16.7						
Gas gangrene	1	4.7			1	20.0	1	33.3		
Infection			4	57.1	1	20.0				
Infection	5	23.8	3	43.0	2	40.0			1	25

Summary 40 open fractures  
11 became infected } Incidence of infection 27.5%

TABLE VIII.—COMPOUND FRACTURES TREATED IN FIRST THREE MONTHS OF 1934

Method of treatment	Therapeutic		Radiation		Fluorouracil		Tissue		Systemic	
	No.	%	No.	%	No.	%	No.	%	No.	%
	1	2	3	4	5	6	7	8	9	10
Primary excision		2		100		100		15		
Open wound		1						15		
Dekia										
Cast		17		100		100				
Traction		17				100		30		
Amputation to control infection										
Traumatic amputation								30		
Gas gangrene										
Infection		12	4					30		

Summary	open fractures, total became infected	} Incidence of infection, 27.2%
---------	--	---------------------------------

debridement implantation of 5 grams of sulfanilamide and suture of the skin, a small puncture wound was discovered corresponding to a fracture in the lower one-fourth of the fibula. The surgeon closed this wound with only superficial debridement and without sulfanilamide. The tibial wound healed without infection. Osteomyelitis developed in the

TABLE IX.—COMPOUND FRACTURES TREATED WITH LOCAL SULFANTILAMIDE  
(March 21, 1948 to December 1, 1941)

Method of treatment and complications	Thrombo- Phlebitis		Eradic. Ulcer		Pilonidal Mistakenly Treated		Fistulae		Flametti		Graft Reversal Other Injury		Compounded disabilities	
	Ka.	%	Ka.	%	Ka.	%	Ka.	%	Ka.	%	Ka.	%	Ka.	%
	64	30	27	87	64	30								
Primary cases	64	95	27	88	13	82	30	90		300		0.5	1.5	20
Sliding grafts		22.2		24				27						
Open wound						27								
Internal fistulae	13	20						15		1.5				
Cas		98	28	87	27	80		18				0.5		20
Traction	25	70			1.5	1.8		05		7.7				
Traumatic amputation								4.5		1.5				
Infection*	07	27					7							
Gum gangrene														
Amputation to control infection														
Death†	included		1.5		(Total 1977 Cancer of Death Reported spleen in stomach 24 ulcers in perist Medical)									
	not included													

Summary	of open fractures secondary infections	incidence of infection	%
1. 1st	1	1	100
2. 2nd	1	1	100
3. 3rd	1	1	100
4. 4th	1	1	100
5. 5th	1	1	100
6. 6th	1	1	100
7. 7th	1	1	100
8. 8th	1	1	100
9. 9th	1	1	100
10. 10th	1	1	100
11. 11th	1	1	100
12. 12th	1	1	100
13. 13th	1	1	100
14. 14th	1	1	100
15. 15th	1	1	100
16. 16th	1	1	100
17. 17th	1	1	100
18. 18th	1	1	100
19. 19th	1	1	100
20. 20th	1	1	100
21. 21st	1	1	100
22. 22nd	1	1	100
23. 23rd	1	1	100
24. 24th	1	1	100
25. 25th	1	1	100
26. 26th	1	1	100
27. 27th	1	1	100
28. 28th	1	1	100
29. 29th	1	1	100
30. 30th	1	1	100
31. 31st	1	1	100
32. 32nd	1	1	100
33. 33rd	1	1	100
34. 34th	1	1	100
35. 35th	1	1	100
36. 36th	1	1	100
37. 37th	1	1	100
38. 38th	1	1	100
39. 39th	1	1	100
40. 40th	1	1	100
41. 41st	1	1	100
42. 42nd	1	1	100
43. 43rd	1	1	100
44. 44th	1	1	100
45. 45th	1	1	100
46. 46th	1	1	100
47. 47th	1	1	100
48. 48th	1	1	100
49. 49th	1	1	100
50. 50th	1	1	100
51. 51st	1	1	100
52. 52nd	1	1	100
53. 53rd	1	1	100
54. 54th	1	1	100
55. 55th	1	1	100
56. 56th	1	1	100
57. 57th	1	1	100
58. 58th	1	1	100
59. 59th	1	1	100
60. 60th	1	1	100
61. 61st	1	1	100
62. 62nd	1	1	100
63. 63rd	1	1	100
64. 64th	1	1	100
65. 65th	1	1	100
66. 66th	1	1	100
67. 67th	1	1	100
68. 68th	1	1	100
69. 69th	1	1	100
70. 70th	1	1	100
71. 71st	1	1	100
72. 72nd	1	1	100
73. 73rd	1	1	100
74. 74th	1	1	100
75. 75th	1	1	100
76. 76th	1	1	100
77. 77th	1	1	100
78. 78th	1	1	100
79. 79th	1	1	100
80. 80th	1	1	100
81. 81st	1	1	100
82. 82nd	1	1	100
83. 83rd	1	1	100
84. 84th	1	1	100
85. 85th	1	1	100
86. 86th	1	1	100
87. 87th	1	1	100
88. 88th	1	1	100
89. 89th	1	1	100
90. 90th	1	1	100
91. 91st	1	1	100
92. 92nd	1	1	100
93. 93rd	1	1	100
94. 94th	1	1	100
95. 95th</			

One patient and one physician, of course, are selected. It also appears in several  
one having second chance supply by secondary infection may be contaminated.  
One of these was not treated with an antibiotic and hence was included in the  
group. The patient was internally healed (see adequately) and was subsequently  
re-examined. All cases of ectopic. These that lived, days or longer after  
re-examined at autopsy and none were found to be infected in that group. T-

that would be a delay  
- the system  
- the system  
- the system

fibula. In this case, the circulating sulfanilamide absorbed from the tibial wound failed to prevent infection in the fibula. Furthermore, because of this experience and one which we have observed recently (see footnote, Experiment 5) in which only superficial débridement was done and sulfanilamide stuffed into the deeper wound with the subsequent development of gas gangrene demanding amputation of a youth's right arm, we are convinced that our policy of careful, complete débridement of all compound fracture wounds is imperative. The conception of a so called "minimal" compound fracture is about as sound as if one referred to "minimal" carcinomas and recommended that conservative treatment be carried out for them.

The foregoing 3 cases do not represent primary wound infections of compound fractures which were treated with local sulfanilamide. However, they teach in each case a valuable lesson.

Seven primary wound infections did occur, however. These resulted from our failure to establish and maintain in these wounds the local conditions essential for the bacteriostatic action of sulfanilamide.

In 2 compound fractures of the tibia with extensive skin loss, primary closure was attempted. Despite counter-cutting and the fashioning of sliding grafts, closure of the defect was under considerable tension and the skin flaps developed ischemic necrosis. This autolyzing tissue inactivated the sulfanilamide, and osteomyelitis developed. After several months, amputation was elected in 1 case. It is significant that in both instances the surgeon in his operation report dictated several days before infection became evident, complained that closure had to be accomplished under great tension. We now believe that these cases could be satisfactorily treated by the open procedure.

The third primary infection developing in a compound tibia, we believe, resulted from inadequate immobilization of a fracture in the middle third of the shaft. A junior resident, just after coming on the service, attempted to immobilize this fracture in a confused senile male by means of skeletal traction and a posterior plaster splint only. The absence of an

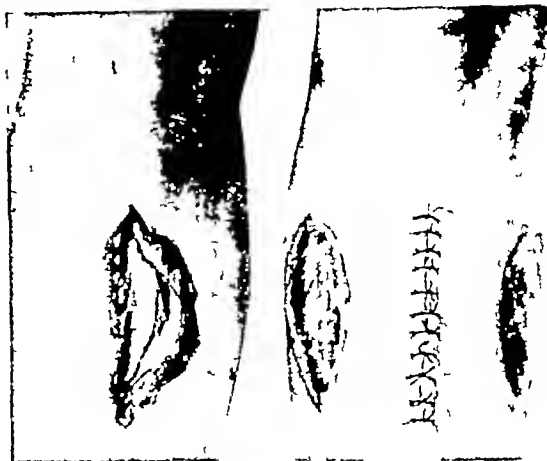


Fig 6 a, Compound fracture with extensive loss of soft tissue. b, Closure of wound accomplished by liberating lateral incisions. (From Cannady, *Ann Surg*, April, 1929)

anteromedial splint allowed excessive motion. Maceration of the wound including the sutured skin overlying the ends of the fragments occurred—infection with localized osteomyelitis followed.

The fourth primary infection occurred in a compound fracture-dislocation of the ankle joint. The wound was very dirty, and in an attempt to save articular cartilage not all the soiled surface was cut away. The wound was thoroughly irrigated with the hope that the cartilage would be cleansed sufficiently thereby. Drainage did not occur, but a chronic destructive arthritis has developed with increased local heat, and certainly bacterial infection is present.

Our experimental studies and these cases indicate that no compromise with adequate débridement can be uniformly successful. If dirt visible to the unaided eye is present in the wound, infection will usually follow, regardless of sulfanilamide.

Extensive maceration of muscle presents a real problem—our fifth failure occurred in such a case. A 16 year old boy struck by an automobile sustained compound fractures of both femora. The left wound was not extensive and a satisfactory débridement and closure was readily accomplished with healing *per primam* and prompt union. At the time of débridement the fragments were wired together

er. On the right side an extensive macerated wound had occurred reaching from above the greater femoral trochanter to the knee and exposing the upper two-thirds of the femur with destruction of the periosteum over the bone. The substance of the vastus lateralis was destroyed by maceration and soiling was extensive. Careful débridement was carried out but completely adequate hemostasis of the extensive muscle surfaces was never attained. A loop of stainless steel wire was passed through drill holes in the fragments. This accomplished approximation but not immobilization of the fragments. The wound was closed with primary suture of the skin after the surfaces were dusted with sulfanilamide. Infection followed, not extensive but definite osteomyelitis of the femur with healing of the soft tissues except for a small sinus tract.

It is also apparent now that the internal fixation was faulty. Approximation of two fragments by passing a loop of wire between their ends does just that. It approximates but does not immobilize. The motion of the wire in the bone results in destruction of bone and this in turn leads to inactivation of sulfanilamide inviting infection.

The sixth and seventh infections represent tragedies. Both were severe *Bacillus welchii* infections associated with hemolytic streptococci. One followed a compound fracture of both bones of the forearm—the other a compound fracture-dislocation of the ankle. Débridement in both instances was hastily performed and examination of the amputated extremities revealed retained foreign particulate matter.

#### SUMMARY OF CLINICAL RESULTS

In summary of the clinical results, our overall incidence of infection from all causes in 22 consecutive compound fractures and 5 compound fracture-dislocations is 4.5 per cent. Two of these however are distinctly due to secondary contamination of the wound occurring after clean noninfected wounds had been obtained. One was not treated with sulfanilamide. This leaves 7 cases of primary wound infection—wounds that became infected as a result of their contamination at the time of

injury. These we feel represent our true failures, an incidence of 3.3 per cent. The explanation of these infections is readily apparent, and it is also as evident that they could have been avoided by known means. In fact, these failures represent lessons we had to learn about the use of sulfanilamide in compound fractures.

*Débridement and immobilization* remain the basic essentials of successful treatment of compound fractures. Any compromise with either will lead to failure in a tragic number of cases. A débridement is good enough only when it has resulted in removal of all the devitalized and soiled tissue. Complete débridement followed by continuous motion at the fracture site is futile for the continued motion remacerates the wound. Minimum immobilization requires splinting of the joint above and below the fracture. In tibial fractures, a hip spica may often be advantageously used in conjunction with skeletal traction.

Evidence is now accumulating that with careful débridement and local sulfanilamide, internal fixation with vitallium can be safely and perhaps advantageously undertaken. In the last year and one half a cautious beginning has been made at the Minneapolis General Hospital and to date (December 1941) 20 compound fractures have been internally fixed without a single instance of wound infection (Figure 7). Internal fixation with appropriate external support solves the problem of immobilization. However great care must be taken to insure solid internal fixation for if screws loosen and the plate slips, it becomes a damaging foreign body inviting sepsis.

The only sutures that belong in a compound fracture wound we feel are those necessary for hemostasis and nerve repair. We prefer interrupted fine silk (not larger than Deknatel C.) for buried ligatures and sutures as well as skin closure. The studies of Shambaugh and Custer and Dunphy showing 50 per cent less infection in contaminated wounds sutured with fine silk seems significant.

There has been much confusion in the literature about the treatment of gas gangrene. However two facts stand out. In controlled experimental infections with various members of the clostridia group, the only

agents which have been found to be of any consistent value are antitoxin and members of the sulfonamide group, and the best treatment that can be offered now is the combination of serum (polyvalent antitoxin) and chemotherapy. Both local and systemic administration of the sulfonamides should be used. Sulfathiazole should be given systemically and a mixture of one part sulfathiazole with two parts sulfanilamide appears from Hawking's studies to be the best for local use. Serum should be given in adequate amounts early (100,000 international units or more). Even with these agents, active surgical measures must be pursued and amputation done before disaster results from temporizing débridement of the obviously involved muscle.

Prevention of these infections is the only really satisfactory solution. Every surgeon who treats traumatic wounds should constantly remember that gas gangrene will not develop unless he leaves behind macerated or ischemic muscle, foreign material (dirt), or large numbers of virulent invasive aerobes. The clostridia alone cannot invade clean viable tissue. If adequate débridement is done and sulfanilamide powder is then implanted in the wound, aerobic infection is unlikely and gas gangrene will not occur. Even so, we believe that prophylactic antigas gangrene serum as well as tetanus antitoxin should be routinely used.

Finally, we wish again to emphasize that sulfanilamide locally implanted is effective only under rather rigid conditions. These conditions can be established by careful radical débridement within 6 to 8 hours after injury, complete immobilization, and appropriate measures to maintain good circulation and body temperature, or slightly above, in the wound. It may be that even under adverse military circumstances, the severity of infections will be greatly lessened by prophylactic local sulfanilamide. There is yet, however, no incontrovertible data on this phase of the problem, although the observations of Leonard Colebrook and many others (2, 10) in England seem to support this view.

The possibility that one of the new sulfonamide compounds will be found more effective as a local prophylactic agent is good, and

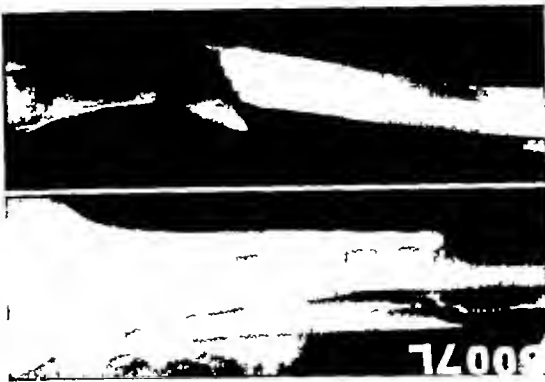


Fig 7 Roentgenograms of a compound fracture of a tibia before and after débridement and reduction with internal fixation. Vitallium plate and screws used. Note length of plate and selection of screws so that each screw transverses both cortices of the tibia.

this phase of the problem is under investigation. The studies of Dubos on antibacterial substances liberated by sporulating soil bacilli, and of Chain of England of the antibacterial substance elaborated by a mold closely related to *Penicillium notatum* offer very great possibilities which demand investigation.

#### SUMMARY

- 1 The basic treatment of compound wounds is débridement and immobilization.
- 2 The addition of local sulfanilamide implantation to this basic treatment reduced the incidence of infection in compound fractures treated at the Minneapolis General Hospital from approximately 27 per cent to 3.3 per cent.
- 3 Local implantation of sulfanilamide in compound fractures reduced the average hospital stay per case from 96.3 to 30 days.
- 4 Two cases of gas gangrene occurred, less than 1 per cent, in 212 consecutive compound fractures treated with local sulfanilamide, while 7.3 per cent of the control series treated without sulfanilamide developed gas gangrene.

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# PULSATING TUMORS OF THE ANTERIOR MEDIASTINUM

J. SHELTON HORSLEY, M D, F A C S, Richmond, Virginia

**A**NEOPLASM that arises in the anterior mediastinum and erodes through the sternum by transmitted pulsation from the aorta is extremely rare. Sir James Paget, in 1896, stated that "malignant disease of the chest wall receiving pulsation from the heart has been mistaken for aneurysm. The converse error has also been committed."<sup>1</sup>

The most common origin of a pulsating mass in the sternum is an aneurysm of the aorta. Aneurysms of the internal mammary artery also occur and may erode the adjacent bone, but such erosions are usually along the margin of the sternum and the adjoining costal cartilage. It is, of course, conceivable that an aneurysm of this vessel may project to its median side and perforate the sternum.

In an excellent study of pulsating tumors of the sternum George Crile, Jr., states that no verified case of pulsating sarcoma of the sternum could be found in the literature. It is well known, however, that pulsating sarcoma of bone, the so called bone aneurysm, occurs elsewhere. Crile reports 13 cases of pulsating neoplasms of the sternum that have been reported in the literature, and adds 5 more from the records of the Cleveland Clinic. Of this entire group 9 were probably cases of metastatic hypernephroma, or adenocarcinoma of the kidney as it is now termed, and 9 were probably metastases from malignant adenomas of the thyroid.

The following case of pulsating tumor involving the sternum, though not originating in the sternum, presents unusual and interesting features.

## CASE REPORT

C. L. G., white male, 74 years of age, was admitted to St. Elizabeth's Hospital on July 8, 1940, complaining of a pulsating growth in the upper sternum, slightly to the right of the midline. He first

noticed it about 4 months prior to admission. It had gradually increased in size. It had never been tender or painful.

Dr. Roy W. Upchurch, of Danville, Virginia, had performed a left nephrectomy on the patient on May 23, 1933. There was an impacted stone in the lower third of the left ureter. The kidney was a pyonephrotic sac full of pus. There was no evidence of malignant neoplasm. On July 10, 1933, Dr. Upchurch had done a transurethral resection of an enlarged middle lobe of the prostate. The pathological report on the tissue removed showed no cancer but hyperplasia and chronic prostatitis. The patient made a satisfactory recovery from both operations.

**Physical examination.** The patient was in fairly good general condition. Wassermann reaction was negative. Blood and urine were about normal. There was a pulsating mass over the upper manubrium slightly to the right of the midline. The pulsations were expansile and synchronous with the heart beat. There was no bruit. The tumor was about 6 centimeters in diameter and 4 centimeters in elevation (Figs 1 and 2). There were no definite heart murmurs, blood pressure was 170/95, and equal in both arms. Roentgenological examination showed a defect in the upper manubrium. The defect was smooth in outline and about 5 by 4 centimeters in diameter (Fig 3).

Dr. Fred M. Hodges, who made the roentgenological examination, thought the lesion was probably a tumor of the anterior mediastinum. The heart and aorta seemed normal under the x-rays. The expansile pulsations were so obvious that I made a tentative diagnosis of aneurysm of the right internal mammary artery.

Operation under ethylene anesthesia was performed on July 10, 1940. After an incision through the skin and fascia over the tumor, pulsation diminished and ceased completely when some of the surrounding bone was removed (Fig 4). Pulsation had evidently been transmitted from the aorta through the tumor. The tumor was soft and had been firmly held by the fascia. As much of the growth was removed as possible, but it was rather extensive and bled so freely that some of the posterior part of the tumor was left. Five radium needles, each containing 10 milligrams of radium, were inserted, and iodoform gauze was firmly packed into the wound. The wound was partly sutured over the gauze.

The specimen consisted of a large portion of the tumor and other smaller portions. The largest portion measured 5 by 4 by 2.5 centimeters. Its external surface was covered with an apparent capsule which was really fascia and muscle that the growth had pushed forward. The main substance of the

From the Surgical Department of St. Elizabeth's Hospital, Richmond, Virginia.

<sup>1</sup>Paget, Sir James. *The Surgery of the Chest*. Bristol, 1896, quoted by Crile, George Jr. *Ann Surg* 1936 103:199-209.

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Fig. 2. Left. Photograph of pulsating tumor of the anterior mediastinum, slightly to the right of the midline.

Fig. 3. Lateral view of pulsating tumor of the mediastinum.

tumor was soft, almost jelly-like, and of a pale yellow color. Adherent to its outer surface were several spicules of bone which became attached as the tumor eroded through the sternum. There were three other pieces of the tumor. The largest of these measured 3 by 5 by 5 centimeters. Microscopically the tumor consisted chiefly of epithelial cells with very scant stroma. The cells varied in size and shape, round, polyhedral, cubical or columnar. Through-

out most of the microscopic field the cells were arranged in a solid-like formation. Occasionally the cells were quite distinct and contained large, clear, columnar cells. Other portions of the field showed the cells packed rather closely together. In many places the cells resembled somewhat those of an adenocarcinoma of the kidney. It had almost clear cytoplasm and a small nucleus. The cytoplasm sur-

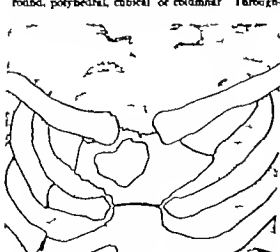


Fig. 3. Sketch from the ray picture showing outline of the erosion in the sternum.



Fig. 4. The tumor with its covering of fascia and muscle has been exposed at operation.



Fig 5 Photomicrograph of tumor. It shows the structures described in the text with the acinous formation, clear cells and other cells packed in close formation.  $\times 150$

ally was slightly granular. There were a few clear cells without nuclei, such as are found in the so called hypernephroma. The tumor was undoubtedly malignant. The histological structure did not clearly indicate its origin (Figs 5, 6, and 7). Some pathologists thought it was a metastatic hypernephroma from the kidney even though it showed acini. It would be unusual to find a single metastasis at some distance from the original lesion with no metastases elsewhere. Such a thing is possible but not probable. Dr A C Broders called the tumor an adenocarcinoma, grade 3, but was uncertain as to its origin. There was no evidence of an origin in the bone. The margin of the bone removed in order to obtain access to the growth seemed normal in structure. There was merely erosion as a result of the pressure of the tumor.

*Subsequent course* Two days later, when the radium and packing were removed, there was profuse bleeding which was controlled by packing with iodoform gauze. An attempt was made to remove the gauze 5 days after the operation, and there was again active bleeding, so the wound was opened and the vessels were controlled by sutures.

One week after the operation x-ray therapy by Dr Hodges was begun. There were 7 treatments.

As the lesion was rather superficial, instead of using

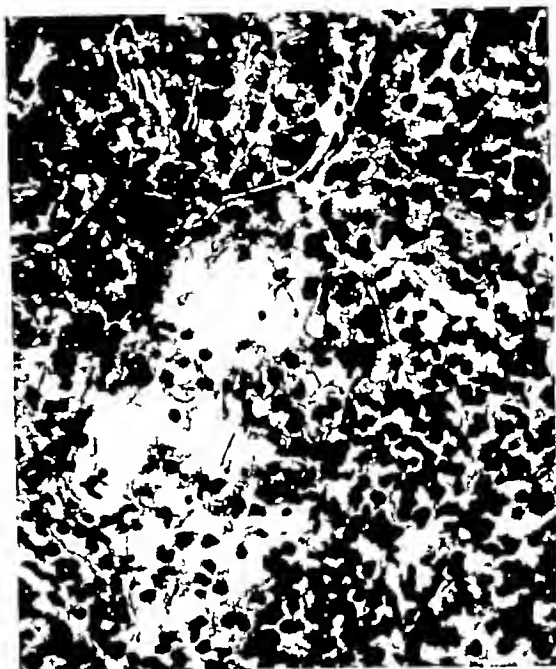


Fig 6 Photomicrograph showing blocked off area on the left side of Figure 5 enlarged to  $\times 300$ . Note the clear cells and at the top an acinous formation.



Fig 7 Higher magnification,  $\times 300$ , of the blocked off area on the right side of Figure 5. Note the distinct acinous formation of columnar cells with slightly granular and almost clear cytoplasm. The surrounding cells of different sizes and shapes are packed rather closely together.



Fig. 1. Left. Photograph of pulsating tumor of the anterior mediastinum, slightly to the right of the midline.

Fig. 2. Lateral view of pulsating tumor of the mediastinum.

tumor as soft, almost jelly-like and of pale yellow color. Adherent to its outer surface were several spicules of bone which became detached as the tumor eroded through the sternum. There were three other pieces of the tumor. The largest of these measured 3 by 3 by 3 centimeters. Microscopically the tissue consisted chiefly of epithelial cells with very scant stroma. The cells varied in size and shape—round, polyhedral, cubical, or columnar. Through-

out most of the microscopic field the cells are arranged in disorganized formation. Occasionally the nuclei were quite distinct and contained large chromatin cells. Other portions of the field showed the cells packed rather closely together. In places the cells resembled somewhat those of an adenocarcinoma of the kidney with almost clear cytoplasm and small nuclei. The cytoplasm re-



Fig. 3. Sketch from the X-ray picture showing outline of the erosion in the sternum.



Fig. 4. The tumor with its covering of fascia and muscle has been exposed at operation.

columnar and cubical epithelium. Such rests might be from the lateral primordia of the thyroid from the fourth branchial groove, from the third branchial pouch which forms the thymus, or from the third and fourth branchial pouches from which the parathyroids arise. This does not necessarily call into consideration the ultimobranchial transient structures.

#### CONCLUSION

No positive statement as to the exact histological origin of this unusual neoplasm

seems possible now. If the Pancoast tumor is accepted as arising from a primordium of one of the branchial structures carrying squamous epithelium, it would be probable that this tumor could arise from a branchial primordium of columnar or cubical epithelium. If it be assumed that the histological origin of the tumor is from the thymus, it would naturally originate from the early stages of the thymus in which the structure is epithelial and before it has been taken over by the lymphocytes.





Fig. 8 Photomicrograph of tissue obtained at biopsy from the depth of the wound about 4 weeks after the roentgenological treatment. This shows practically complete degeneration of the neoplastic cells. X

deep therapy the patient was given 3 Millivolts—6 millimeter aluminum filter 7 minutes—approximately 800 roentgens. The patient was transfused with blood three times. He was discharged from the hospital a month after the operation.

He returned 3 weeks later when he was in fairly good condition. The wound had not healed. There was no pulsation. Biopsy from the wound showed extensive degeneration of the neoplastic cells obviously caused by the irradiation (Fig. 7). The cavity left after the operation was large. Efforts to close it were made by sliding flaps from adjacent tissue. On discharge from the hospital the wound almost healed. The granulations seemed healthy. On December 5, 1920, the patient again returned and further plastic operation was done.

A letter received from the patient's family physician, Dr. Girard V. Thompson, of Chatham, Virginia, dated November 9, states that there is no evidence of any recurrence of the tumor and that the patient's general health is good. The wound, he writes, has almost healed but occasionally sinus opens from which speckles of bone are extruded. At operation portions of the sternum and the inner end of the right costal cartilage of the second rib were removed.

Morris and Harken report several cases in which the diagnosis of a so called Pancoast tumor seems to be substantiated. Pancoast, in 1933 described an intrathoracic growth which he termed a superior pulmonary apex tumor. The distinctive features of this tumor are that it is located in the posterior thoracic inlet adjacent to the pulmonary apex, the histological structure is that of an "epidermoid carcinoma" the site of origin is demonstrably independent of the neighboring lung, pleura, ribs, vertebrae, mediastinum, or metastatic foci. Clinically according to Pancoast, this tumor produces Horner's syndrome, which the writers show is really Hare's syndrome, for Hare described this symptom complex in 1869, 31 years before Horner did. The neoplasm also causes pain referred to the shoulder and arm, associated with muscular atrophy and there is roentgenological evidence of a small homogenous apical shadow suggestive of destructive infiltration of contiguous ribs and vertebrae. Morris and Harken conclude that there may exist at the pulmonary apex an epithelial neoplasm which fulfills these specifications and is entitled to be classed as a clinical and pathological entity.

Pancoast believes that there are persistent rests from the ectodermal portion of the branchial structures which serve as primordial origin for the neoplasm he describes.

According to Jordan and Kindred<sup>1</sup> the parathyroids arise from the upper portion of the third and fourth branchial pouches, the thymus comes from the third branchial pouch, and the lateral primordia of the thyroid gland are in the fourth branchial pouch. Below the fifth branchial arch are the ultimobranchial groove and body, a region of romance for the origin of unusual tumors. It would seem, then, that if the Pancoast tumor which Morris and Harken confirm as a pathological and clinical entity does arise in the upper thorax from a branchial rest and is always composed of a squamous type of epithelium, there may also be a tumor as the one herewith reported, originating in rests from the portions of the branchial grooves or pouches that give ectodermal or

<sup>1</sup>Odessa, John H. and Harken, Dwight E. *Ann. Surg.* 1926, 21, 17.

<sup>2</sup>Jordan, Harvey E., and Kindred, James E. *A Textbook of Embryology*. New York: D. Appleton and Co. 1904.

<sup>3</sup>Thorough check up of patient April 4, 1927, by 3 ray and other examination reveals no evidence of recurrence, general health good, chest and mediastinum perfectly clear.

coughing and in the course of a few minutes expectorates a large quantity of pus. This is always a difficult and trying experience and is occasionally more than a debilitated patient can survive. Sudden death from drowning may occur. Flooding of the lungs with pus may produce a progressive and fatal bronchopneumonia. If the patient survives these immediate hazards he is usually benefited by the drainage of the abscess. The fever may fall to normal, cough and expectoration may gradually subside, and spontaneous complete recovery may occur. This is rare, only 3 such cases having been reported. More often the patient continues in a more or less septic state and with persistent cough and expectoration. Not infrequently the abscess drains intermittently. When the tract becomes plugged, cough and expectoration cease, and the temperature rises. Such spells are usually followed by re-rupture of the abscess. Between spells of plugging of the tract the temperature may be nearly normal.

The physical findings vary greatly and rarely give a clue to the diagnosis. Evacuation of the pus permits the diaphragm, which before rupture is usually high, to resume its normal position. It also relieves the pain and deep tenderness which are important findings in acute subdiaphragmatic abscess. These may recur if the drainage becomes temporarily stopped. Hoover's sign, an increased movement of the lower ribs on the affected side, disappears with the descent of the diaphragm. One's belief that the symptoms are caused by pulmonary disease may be strengthened by finding signs of scattered areas of pneumonitis which are secondary to the purulent expectoration.

#### ROENTGENOGRAPHY AS AID TO DIAGNOSIS

Next to the history, the roentgenogram gives the most important diagnostic information. The most characteristic finding is a greater or lesser elevation of the diaphragm with air and a fluid level beneath it. Neither the elevation nor the air and the fluid level are always present. There may be no more than evidences of old pleurisy at the base. The findings in the lungs and pleura above the diaphragm vary greatly. The perforation may

have produced an empyema as well as a bronchial fistula (as in one of Steele's cases) in which situation the picture is that of empyema with bronchial fistula. In acute cases there may be extensive bronchopneumonia in the lower lobe on the affected side. In more chronic cases, areas of chronic pneumonitis may be present in one or both lungs. Not infrequently pulmonary and pleural findings are almost entirely absent, consisting merely of increased peribronchial markings extending into one lower lobe. The meagerness of thoracic findings in the presence of fever and copious expectoration is one of the important diagnostic points. In such cases it is necessary to employ bronchography to rule out bronchiectasis, but when this has been done and one is still unable to explain the abundant expectoration on the basis of revealed pulmonary or pleural pathology, it is well to consider the possibility that the pus is coming from below the diaphragm.

When patients are seen later in the course of the disease, it is important to gain access to all of the x-ray films which have been taken. Those taken before or immediately after the perforation may present characteristic findings.

If there is much pleural thickening at the base of the thorax, only x-ray pictures taken with heavy penetration will reveal air or fluid below the dome of the diaphragm.

#### DIAGNOSTIC PNEUMOPERITONEUM

X-ray pictures taken after the injection of 300 to 400 cubic centimeters of air into the peritoneal cavity are of great value. Under normal conditions with the patient in the upright position, these will reveal air beneath both halves of the diaphragm. In the presence of subdiaphragmatic abscess, no air can penetrate into this space on the affected side. If the under surfaces of the diaphragm are free, pus in this region can be ruled out.

The induction of pneumoperitoneum is an extremely simple and safe procedure. One simply thrusts a blunt pneumothorax needle (Kuss needle) well through the parietal peritoneum below the left costal margin and permits the air to flow in from a pneumothorax apparatus. With the blunt needle there is no

# SUBPHRENIC ABSCESS WITH BRONCHIAL FISTULA

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THE too obvious deduction that cough with production of large amounts of sputum is evidence of primary intra-thoracic disease is a frequent cause of serious diagnostic errors. It is not always known and if known is not easily remembered, that hepatic, subdiaphragmatic, and perinephritic abscesses frequently perforate the diaphragm and are evacuated by expectoration. While a few patients are cured by such spontaneous drainage and while some others die early from spreading pulmonary or pleural infection in many instances the condition becomes chronic and the patient partially recovered is left with a persistent or intermittent productive cough. The purpose of this paper is to report 3 cases of chronic subdiaphragmatic abscess with bronchial fistula.

It is a paradox of pathology that collections of pus in the upper abdomen frequently burrow upward through the diaphragm whereas similar collections in the thorax rarely if ever extend downward into the abdomen. In a series of 3,608 cases of subphrenic abscess collected by Ochsmier and DeBakey there were only 89 in which pleural or pulmonary infection was believed to have been primary. There were none in the authors' 75 cases. Inasmuch as the first important symptoms and signs of subdiaphragmatic pus are often those incident to extension to the pleura or lungs, and inasmuch as this entity is frequently mistaken for pleurisy, pneumonia, or lung abscess, it is reasonable to believe that in many of the 89 cases reported the subdiaphragmatic did actually precede the supradiaphragmatic lesion. It is quite possible that downward extension does not occur.

In 1937 Steele reported 6 cases of subdiaphragmatic abscess with bronchial fistula and

reviewed the literature. In 1902 Caudern was able to collect 20 cases, and in 1909 Piquand in a collected series of 890 cases of subphrenic abscess, found 112 with diaphragmatic penetration and bronchial evacuation, an incidence of 12.6 per cent. Between 1909 and 1937 Steele found records of 13 additional cases. In 1938 Ochsmier and DeBakey analyzed 3,608 collected cases of subdiaphragmatic abscess. In 1,380 cases in which information was sufficiently detailed simple pleurisy occurred in 27.7 per cent perforation with empyema in 17.8 per cent perforation with bronchial fistula in 10.5 per cent, and perforation with pericarditis in 5.1 per cent. The total incidence of perforation of the diaphragm was 33.4 per cent. There were 2 instances of spontaneous evacuation through the chest wall.

The serous sterile pleural effusions which occur in many cases—27.7 per cent in Ochsmier and DeBakey's series—are not evidence of perforation and are not of great clinical significance.

The incidence of perforation of the diaphragm is so high that this complication is to be expected when operation is too long delayed. Ochsmier and DeBakey stress the fact that thoracic complications are definitely attributable to late diagnosis or to procrastination in treatment. While this statement is largely correct it is not entirely so. In Caudern's 20 cases the interval between the etiological disease or operation and the perforation varied between 10 days and 23 months. In Steele's cases the limits were 13 days and 18 months with an average interval of 18 weeks. It is evident that in occasional cases perforation occurs early.

## CLINICAL PICTURE

The perforation of a subdiaphragmatic abscess into a bronchus is usually sudden. A patient who has presented the picture produced by encapsulated pus suddenly starts

From the Thoracic Surgery Service of the Veterans Administration, Hines, Illinois.

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Fig 2 Case 2 The fixed right diaphragm with minimal pulmonary findings insufficient to account for the copious expectoration suggested the diagnosis. Diagnostic pneumoperitoneum has been performed. There is air beneath the left diaphragm but none beneath the right. This is corroborative evidence of a subdiaphragmatic lesion.



Fig 3 Case 2 Lateral film showing opacity under anterior part of right diaphragm.

about 2 inches and then bulging outward into the lung field, where on the upper surface it shaded off into normal findings. This had the appearance of fluid in the pleural cavity. On the lateral film the residuals of lipiodol could be seen outlining a high right diaphragm.

Thoracentesis was done over the seventh rib in the nipple line, right, and at a depth of  $3\frac{1}{2}$  inches sour smelling pus was obtained. With the patient flat on his back and under local anesthesia, a 2 inch segment of the seventh rib in the nipple line was resected. Cautious layer by layer incision revealed an adherent pleura and also revealed the fact that the incision was being carried through the diaphragm. Aspiration was done through the periosteal bed and similar sour smelling pus was found. A knife was inserted along the shaft of the needle and a large pocket of pus was entered. The opening was enlarged by spreading by a blunt hemostatic forceps. Digital examination revealed a large abscess cavity situated below the diaphragm and extending beyond the reach of the examining finger posteriorly. The size of the cavity could be approximated roughly as being about as large as a grapefruit. As much pus as possible was evacuated, and a large drainage tube was inserted. The wound was packed wide open with mercuriochrome gauze.

CASE 2 This patient had had a peptic ulcer for many years, the diagnosis having been made by

several physicians. He gave a history of having been treated for this ulcer ever since his service in the World War. During the first part of December, 1936, while drinking a cup of coffee in a restaurant, he was suddenly seized with an acute, knife-like pain in the abdomen. This pain came on about 5:30 p.m. He was taken to a hospital and operation was performed at 12 o'clock midnight. A ruptured gastric ulcer was found. What treatment was applied at the time of operation is unknown. The patient said that he had been free from symptoms referable to his stomach since the operation. He reported that several drainage tubes were left in the abdominal wound.

About 30 days after the operation the patient developed a severe pain in the lower right side of his chest and about the same time developed pain at the point of his right shoulder and the right side of the neck. These new pains did not cause any particular concern among his medical attendants and continued uninterrupted and unchanged. Shortly after the onset of these pains he developed a dry cough.

The drainage tubes were removed from the abdominal wound in April and by the latter part of May the wound was completely healed. Sometime during this interim, during a spell of coughing, the patient said he raised a plug of dark, reddish-brown material which he likened in shape to a section of toothpaste squeezed from a tube. Following the bringing up of this plug he raised brownish chocolate sauce material



Fig. Case. Chronic subdiaphragmatic abscess with bronchial fistula of 3 years' duration. The slightly elevated, fixed right diaphragm with basal lung findings insufficient to account for the copious empyema, suggested the diagnosis. Condition followed operation for ruptured peptic ulcer.

danger of injuring the bowel. If the needle is not in the free peritoneal cavity the air will not flow. One can verify the fact that the air is entering properly by noting the rapid disappearance of the liver dullness.

#### EXPLORATORY ASPIRATION

In acute unperforated subphrenic abscess exploratory aspiration is dangerous. It is practically impossible to reach the pus without passing the needle through the free pleural cavity. Leakage of pus into this space may cause acute empyema. In a chronic abscess which has already perforated the diaphragm, one can assume that the layers of the pleura are adherent and can use the exploratory needle with impunity. Operation should not be undertaken until the pus has been thus located. Localized tenderness and the x-ray film, especially that taken in the lateral position, will usually indicate the probable site

#### PROGNOSIS

In Steele's series of 48 cases of subphrenic abscess seen at the University Hospital at Ann Arbor the mortality was 50.8 per cent. Of the 6 patients with bronchial fistula 3 died, a mortality of 50 per cent. In the Ochsner and DeBailey personal series, the mortality in

those with thoracic complications was 50 per cent as against 16.3 per cent in the uncomplicated abscesses.

#### TREATMENT

Only 2 of the many reported cases of subphrenic abscess with bronchial fistula are known to have recovered spontaneously. In these health was regained only after a long and debilitating illness. The event is so rare that it should never be expected or operation delayed in the hope that it will occur. The treatment is the same as that of uncomplicated subphrenic abscess, namely incision and drainage. In these cases the pleurae are usually adherent and in a single stage one may go directly to the pus at the point where it is nearest to the chest wall and where it has been located by the needle.

#### CASE REPORTS

CASE. A 35-year-old police officer entered the hospital January 24, 1920, complaining of cough productive of large amounts of foul smelling sputum, fever, loss of weight, and weakness. In 1918 he is reported upon for ruptured peptic ulcer. Following this he continued to run a fever for some time and did not regain his weight or strength. He had been chronically ill ever since, having pain in the right upper quadrant of the abdomen and right lower thorax. Because of these persistent symptoms and recurrences of fever, he was again operated upon in 1921 for relief of adhesions. This did not relieve his symptoms. In 1924 he was operated upon for gall bladder disease. More adhesions were freed, but the gall bladder was found to be normal and was neither drained nor removed. Since then he had continued in poor health and had had frequent attacks of fever the temperature occasionally rising to 102 and 103 degrees. In October, 1930, he became acutely ill with lung condition which his physician called pneumonia.

Examination revealed a rather poorly nourished white male, semilambulant and appearing quite ill. The right side of the chest was less mobile than the left, the abnormal physical findings being limited to the base of the right lung where vocal fremitus is diminished anteriorly, resonance diminished at the base anteriorly and in the midaxillary line and with marked diminution of breath sounds and whispered and spoken voice conduction in this area. No rales were heard.

The teroposterior and lateral x-ray films taken January 30, 1931, revealed an extremely high right diaphragm with some thickening of the pleura above it and some residuals of lipiodol still in the bronchi. This lipiodol examination was made elsewhere. There was uniform opacity about 1 inch across extending from the diaphragm up the lateral chest wall for



Fig 5 Case 3 Lateral roentgenogram showing the accumulation of air and of pus beneath the posterior part of the right diaphragm



Fig 6 Case 3 Condition after operation. Note that the parenchymal infiltrations throughout both lungs have almost disappeared

first place. He returned to the same civilian hospital where he stayed for about a week. While in the hospital the second time he began to cough up greenish, foul smelling pus. He returned to his home where he remained about 4 weeks, during which time he continued to expectorate 3 or 4 cupfuls of extremely heavy, foul smelling pus daily.

At the time of admission to this hospital for treatment, the patient was very poorly nourished, running an irregular temperature with moderately high afternoon elevations. He was raising one-half cupful of foul smelling sputum daily. X ray films showed an air bubble beneath the right leaf of the diaphragm which contained a fluid level. Patient was tender under the right costal arch.

Due to the long duration of the infection, it was felt that there were dense adhesions between the pleura and the diaphragm. Accordingly, the patient was taken to the operating room and a 3 inch segment of the 11th rib, posterior, right, beginning 2 inches from the spine, was resected. The periosteal bed was found to be thickened and fibrosed. The aspirating needle was passed through the bed of this rib upward and toward the spine, and thick pus was found. The knife was passed along the shaft of the needle and the opening dilated with blunt hemostatic forceps. Although no definite pocket of pus was found, the entire area was generally thickened and

fibrosed. At a later date an operation revealed a small pocket which was opened and a considerable quantity of pus drained. This was packed and eventually a drainage tube was inserted. Still the patient did not effect a complete recovery until on April 3, 1941, he was reoperated upon and another pocket found under the 8th rib in the anterior axillary line, right. After drainage of this pocket the patient made a complete and uneventful recovery.

#### SUMMARY AND CONCLUSIONS

- 1 Three cases are reported in which a subphrenic abscess perforated the diaphragm and was evacuated through the bronchi.

- 2 In a collected series of 890 cases, Piquand found that this complication occurred in 12.6 per cent. In a later series of 3,608 cases Ochsner and DeBakey found that it occurred in 10.5 per cent.

- 3 The complication usually occurs late and is a result of delay in diagnosis or treatment. It may develop as early as the tenth day of the disease.

- 4 The patients may die suddenly by drowning in the pus, they may die in a short

time of acute bronchopneumonia, or may live for many years suffering from low grade sepsis and a chronic or intermittent productive cough.

5 In Steele's series of 48 cases of subphrenic abscess, the mortality was 50.8 per cent. Three of his 6 patients with bronchial fistula died a mortality of 50 per cent. In a personal series of 75 cases of subphrenic abscess reported by Ochsner and DeBakey the mortality in those with thoracic complications was 50 per cent as compared with 16.3 per cent in those without this complication. The

3 patients whose histories are the basis of the present report all recovered following operation.

6 Although an occasional patient will recover without operation the institution of open drainage is urgently indicated.

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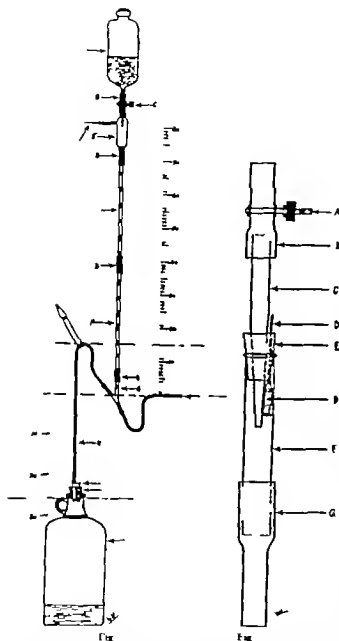


Fig. 1. Contained tidal irrigator and cystometer drainage scale. *A*, Reservoir. *B*, Small sections of rubber tubing connecting the reservoir, drop delivery bulb, glass manometer tubes and *Y* tube. The size and adjustment of the rubber connections below the drip bulb should be such as to cause no local constrictions in the system. *C*, Small screw clamp to control rate of drip. *D*, *Y* tube attached to side arm of drop delivery bulb by rubber tube. *A*, gauge hypodermic or blood needle has been shown that allows the right amount of air enter when sphygmomanometer starts and yet

not break the sphygmomanometer. *A*, so gauge needle will also serve satisfactory air vent. *ah*, If the rate of drip is rapid. *Z*, Drip delivery bulb with side arm. The inside diameter of the lower end should be approximately  $\frac{1}{8}$  of an inch or more. The lumen of the outlet must not be smaller than the lumen of the manometer tubes, otherwise air locks may form and interfere with operation. (See Figure for improved drip delivery bulb arrangements.) *F*, Manometer. Glass tubing 70 centimeters long with inside diameter approximately  $\frac{1}{8}$  of an inch. The glass tubing is divided into 10 places, each 35 centimeters long, to facilitate sterilization in a container of reasonable size. A centimeter ruler placed along side of the manometer allows pressure readings to be taken at glance. *G*, *Y* tube inside diameter approximately  $\frac{1}{8}$  of an inch. The apex of the *Y* of the *Y* tube is set approximately at bladder level. The apparatus all functions perfectly.

It is set at the level of the top of the mattress. *H*, Rubber sphygmomanometer approximately  $\frac{1}{8}$  of an inch. The height to which this is raised above the bladder level determines the pressure produced in the bladder before sphygmomanometer starts. The length of the tubing below the level of the bladder determines the maximum depth or suction pressure that can be exerted on the bladder. This is lowered somewhat by the air vent valve. In the illustration, the sphygmomanometer loop is about 5 centimeters above the bladder level and the length of the tube below the bladder level is 20 centimeters. The setting for the positive pressure must be determined for each bladder by cystometry. The negative pressure should perhaps not be allowed to exceed 20 centimeters in any case and may be lowered if an acutely inflamed bladder is to be irrigated. It is essential that the lower end of the sphygmomanometer be kept above the fluid level in the container. Hence it is essential that the receptacle *K* should be in rubber stopper *J* with its glass tubes such that one *T* connect with the sphygmomanometer and one *T* to serve as an air vent. For cystometry the only adjustment necessary after the bladder has been emptied is to clamp off the sphygmomanometer. *L*, Rubber tubing  $\frac{1}{8}$  of an inch inside diameter connecting single arm of the *Y* tube to catheter. This tubing is inserted to the mattress so as not to drag on catheter.

*M*, Improved drip tube delivery arrangement. If drip delivery bulb with side arm is not available one can be made up easily from materials about the laboratory. One has used satisfactorily as assembled as follows. *A*, *Y* tube is cut off at the bottom. *A*, rubber stopper *L*, with hole in it is inserted at the top. The glass tube of an eye dropper or glass tube, *C*, pulled out to tapered end, is passed through the cork to deliver the drops. *A* section of rubber tube *B* connects the improved drip bulb with the container and the metal screw clamp, *F*, controls the rate of flow. *A* section of rubber tube, *G*, connects the drip tube with manometer. The air vent consists of hypodermic or blood needle (*F*, or so gauge) is inserted through stopper. Large *T* tube can be made into a drip delivery tube with needle air vent attached to its side arm.

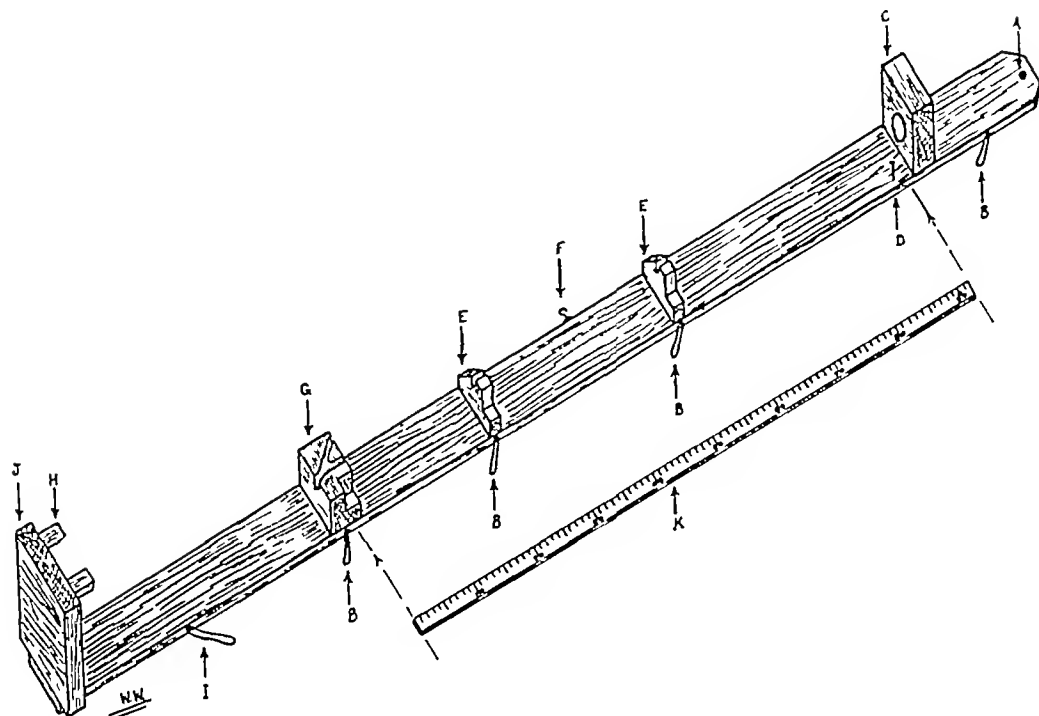


Fig 3 A, Hole in board for suspension from an intravenous stand B, Rubber bands for attachment to screws in sides of board to hold manometer in groove C, Block with hole, through which projects lower end of reservoir D, Nail from which hangs centimeter scale E, Block with center and side cutouts for manometer tubing and centi-

meter scale F, Hook for tape to adjust level of siphon tube G, Block for Y tube and base of centimeter scale H, Triangular blocks to hold receptacle on base of board J, Rubber band to secure receptacle J, Base of board to hold receptacle K Centimeter scale which fits in grooves in Blocks E and G

cycles of filling and emptying of the balloon (Fig 4) before connecting the apparatus to the catheter We make it a practice to sterilize such a balloon with the set each time tidal irrigation is instituted to check the apparatus and instruct the patient It is also important to know the amount of suction exerted on the bladder and the period this suction is exerted before the siphon is broken It can easily be measured by placing a manometer in the system (Fig 5) The duration of the negative pressure is controlled in part by the caliber of the hypodermic needle air vent valve The absolute amount of the negative pressure is determined by the length of siphon tubing below the bladder level However, this is modified by the size of the air vent valve

The desired setting of the siphon loop is determined after cystometry Its height must be just below the level of the intravesical pressure produced by the amount of fluid which the bladder should contain before being emptied For example, if it is estimated that the bladder should not contain more than 250 cubic centimeters, the

siphon level is set just below the pressure produced by this amount of fluid in the bladder The bladder will then automatically empty every time this amount enters it In practice, in determining the number of times per 24 hours the bladder is to be emptied, we have ignored the normal secretion of urine and figured only the number of emptyings which would be produced by the irrigating fluid dropping at a certain rate For example, if the bladder is to be emptied when it contains 250 cubic centimeters of fluid and this emptying is to be done twelve times in 24 hours, the total amount of irrigating solution necessary for this period would be 3000 cubic centimeters The rate of delivery would be 125 cubic centimeters an hour, a little over 2 cubic centimeters per minute or about 50 drops per minute The fluid should be allowed to drip more rapidly causing frequent irrigations if infection or much sediment is present, if not, less frequent irrigations suffice The only contraindication to frequent emptying is the volume of irrigating solution used and the time required to keep the reservoir full

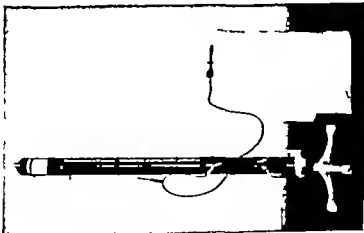


Fig. 4.

Fig. 4. A. Combined tidal irrigation and cystometer. The rubber balloon attached to the catheter is distended with fluid from reservoir. Both pressure of fluid and volume of air can be seen registered in glass manometer. B. Same as except balloon is empty and no post-operative pressure is registered in manometer. Head can be seen in sphincter when contracting.

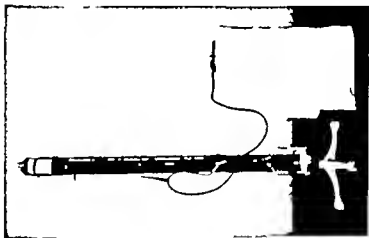


Fig. 4b.

receptacle. The rubber balloon is inflated. When tidal irrigation is started, the patient for the first time and before the apparatus is put into operation, the pattern is shown how it acts in the artificial bladder.

Fig. 5. A sample star manometer connected up as shown was used previously for suction per-

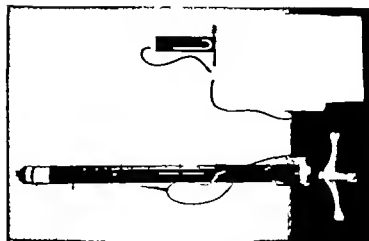


Fig. 5.

wire carried on the bladder at or it as emptied and before air broke the syphon could be altered by raising or lowering the side container. The balloon is empty and the aspirator or suction pressure is demonstrated. Not this be aspirator pressure in the manometer is slightly less than the length of syphon loop before the bladder level.

For cystometry with this apparatus, it is only necessary to close off the siphon tube after the bladder has been emptied. Fluid is then allowed to enter the bladder at the rate of about 120 drops per minute, and pressure readings are taken at 50 cubic centimeter intervals. The patient's first desire to void, if present, is recorded, time of discomfort and distress is also noted. Bladder contractions are charted when they occur. Two recordings are given, one showing the period of areflexia (recording 1) after a cervical spinal cord injury and one (recording 2) illustrating the spinal reflex bladder. These figures can be used to chart curves if graph paper or standard cystometrograph charts are available.

#### RECORDING 1 ATONIC BLADDER

Fluid in bladder—c.c.	Pressure
0	0
50	2
100	2.5
150	3
200	4
250	5
300	6
350	7
400	8
450	8.5
500	9
550	9.5
600	10
650	11
700	12

No sensation noted by patient. Capacity over 700 cubic centimeters. No reflex contractions observed.

#### RECORDING 2 CYSTOMETROGRAM SPINAL REFLEX BLADDER

Fluid in bladder—c.c.	Pressure
0	0
50	7
100	8
150	9
200	10
250	10 -67*
300	12†-90*
350	15 -90*
400	17
450	22
500	17 -90*
550	17‡
600	47¶
650	34

\*Reflex contraction

†Uncomfortable

‡Marked discomfort.

¶Desire to void

Cystometrogram shows a bladder with normal tone, some sensation, and reflex contractions.



Fig 6 Combined tidal irrigator and cystometer attached to indwelling catheter of patient. Y tube is at bladder level. Note pipe cleaner method of retaining catheter in place and the catheter strapped to the patient's leg with adhesive and tube pinned to mattress.

#### SUMMARY

A simple combined tidal irrigator and cystometer for the urinary bladder is described which may be assembled under adverse conditions and which in our hands has advantage over other irrigators we have used. It allows for alternately filling and emptying the bladder automatically to provide tidal irrigation and permits cystometry with only one adjustment. True tidal irrigation must be constantly maintained at optimum rates and pressures to be efficacious and this requires intelligent supervision. We agree with Lawrie and Nathan that the chief applications of tidal drainage are

"1 To prevent the occurrence of infection, it is certainly a life saving measure in 'neurological bladders' as Munro's cases show.

"2 To control the infection of primary cystitis, after oral therapy has failed.

"3 To increase the capacity of a contracted fibrotic bladder by progressively increasing the height of the siphon-tube over a period of weeks.

4. It may be used wherever an indwelling catheter or repeated catheterization is indicated, with the advantages that antiseptic solution is almost continuously in contact with the bladder walls and that it will not allow the progressive contracture of the bladder which occurs with an indwelling catheter draining away continuously."

We have not used tidal irrigation when gonococcal urethritis was present but have not hesitated to start it when urethritis due to an indwelling catheter was a complication at the time of admission. Normal salt or Ringer's solution with dissolved sulfonamides has been used as irrigants with satisfactory results.

Dr. Emerson Smith, urologist in chief of the Royal Victoria Hospital, points out that the weakness in tidal irrigation is the indwelling catheter. There is the danger of ulceration of the urethra and spread of infection to the perurethral tissue, the prostate and epididymis, and to the blood stream. He points out the importance of avoiding traction on the catheter which might traumatize the urethra and advocates, as others using in-

dwelling catheters have done, that the catheter be changed and the urethra irrigated every 3 to 5 days.

To avoid possible trauma we have strapped the catheter to the patient's thigh and pinned the tube connecting the apparatus to the catheter to the mattress. Since these precautions have been observed we have had no complications from indwelling catheters (Figure 6).

We prefer tidal irrigation controlled by cystometry and intelligently supervised to other methods of treatment of the recently paralyzed bladder. In patients in whom it has been proved that voluntary control of bladder function will not return and adjustment to reflex emptying is unsatisfactory we then consider suprapubic drainage.

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# HYDATIDOSIS OF THE LUNG

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ON March 23, 1939, I operated upon a 39 year old patient whose clinical examination revealed the existence of two hydatid cysts, a large one in the left lung and another smaller one in the right lung (Figs 1 and 2)

After a preliminary pneumothorax, we performed an anterior thoracotomy under a local anesthetic, removed 12 centimeters of the 4th rib and evacuated a hydatid situated on the superior lobe of the left lung. The cyst was unilocular and had no daughter vesicles. In accordance with Posadas' method, the incision in the lung was sutured without drainage. Previously a thorough and careful cleansing of the adventitious pouch had been carried out. The incision in the thoracic wall also was closed without drainage.

The wound healed uneventfully and *per primam*. Seven days after the operation x-ray films (Figs 3 and 4) showed that the pneumothorax had disappeared and that the adventitia had shaped itself into a cavity containing a small amount of fluid. The films also showed the unoperated upon cyst in the right lung. The patient

was discharged from the hospital 18 days after his operation and was advised to return for a further operation on the other cyst.

A tomograph, taken 6 weeks later (Fig 5), showed the cyst in the right lung and the adventitious cavity in the left lung. The fluid observed in previous x-ray films had disappeared altogether.

The patient was readmitted to the hospital a little over a year after his first operation, his lung condition is shown in Figure 6. The cyst in the right lung remained unchanged, and on the left side the residual cavity of the operated upon cyst was greatly reduced in size. However, within the well defined though slightly misty limits of this cavity, there was recognized two or three sphere-shaped shadows, the nature of which was unknown. We must confess that, at the time no special importance was paid to these shadows, our attention was wholly concentrated on the cyst in the opposite lung.

The treatment of the cyst in the right lung was carried out a few days later by my colleague, Dr Ivanisovich. With the object of reaching the cyst without having to open the pleura, he resorted to the extrapleural pleuropexis method.



Fig 1 Showing a large hydatid cyst in the left lung and a smaller one in the right, March 3, 1939



Fig 2 Lateral view. The two shadows are partly superimposed, March 3, 1939



Fig. 3. After the first operation. In the left lung, the residual cavity of the cyst shows the presence of a small amount of fluid. In the opposite lung is seen the shadow



of the other cyst, March 30, 1939.

Fig. 4. Lateral X-ray after the first operation, April 26, 1939.

(also called the Lamas-Mondino procedure). Unfortunately a severe inflammatory reaction followed, and abundant serous fluid made its appearance in the pleural cavity (Fig. 7). An X-ray film showed, apart from the fluid in the right pleural cavity, the residual cavity still existing in the left lung and clearly containing 4 or 5 small sphere-shaped shadows, two of them seemingly larger than those seen previously. Later an X-ray film (Fig. 8) showed a total opacity of the right side due to the pleural thickening which followed

the serous pleuritis. This opacity hid the results of the uneventful operation on the cyst (incision, evacuation and drainage) which had been performed 2 months previously. The residual cavity in the left lung was still visible though the round shadows therein had altered their position slightly. Figures 9, 10, 11, 12, 13 and 14 illustrate the evolution and growth of the sphere-shaped shadows in the left lung. These films reproduce only the affected zone of the successive original films. The patient returned to his residence in the country after the skin wound had healed completely and was advised to visit us periodically.

Thirty months after the first operation and 17 after the discovery of the rounded-shaped shadows inside the residual cavity of the left lung, the patient was readmitted to the hospital and X-ray films were taken (Figs. 15 and 16). The pleural opacity of the right hemithorax had cleared considerably. In the left lobe the residual cavity had disappeared and in its place was the typical image of a hydatid cyst. Had we not been aware of the former presence of a cyst in that exact place and of the evolution of its residual cavity we should have been inclined to make a diagnosis of primary hydatid cyst of the lung. Instead, our 7 months' careful observation of the evolution of the cavity allowed us to state that it was a *hydatid recurrence inside the residual cavity of the original cyst*. The general condition of the patient was excellent.



Fig. 5. Tomograph, distance, centimeters, taken after the first operation. No fluid is seen in the residual cavity May 24, 1939.



Fig 6 April 9, 1940 The shadow of the cyst in the right lung and 3 small ones in the residual cavity in the left lung are visible.



right lung, notice the large amount of the fluid in the pleural cavity on that side. The residual cavity of the left lung is shown to have 5 small shadows in the roentgenogram, May 10, 1940

Fig 7 Treatment has been started on the cyst of the

and there were no subjective symptoms of any kind. Until told he should have to undergo a third operation, he thought that our interest was confined to the postoperative results of the earlier operations.

In considering this case, two hypotheses are suggested. First, a new hydatid cyst, developing next to the residual cavity of the previously operated upon cyst, might have grown to the extent of occupying the very same site where the cavity was formerly situated. This line of thought would signify that the new cyst was already present at the time that the first operation had been performed though it was of so small a size that it had escaped detection.

There are two objections to this hypothesis (a) the preliminary pneumothorax—through the total collapse of the lung—would have revealed any other abnormality, (b) had the abnormal element been so small that even the collapse of the lung were not enough to reveal its existence, the palpation of the organ during the operation would have done so. In the case of the left lung we *felt only one tumor*, and only after a year did we suspect that *something else* was developing in the same place. Finally, since the growth of hydatid cysts is a slow process and as we had observed the sphere-shaped shadows grow, so to speak, before our very eyes inside the well defined contour of the postoperative residual cavity, these observations were also opposed to the diagnosis of a new cyst.

The second hypothesis—infection of the adventitious membrane or of the fluid contained within it—is still less likely to hold good. The fluid had disappeared completely without giving rise to either subjective or objective signs and a year later we had seen its place taken by the newly formed shadows. It was, therefore, highly improbable that fluid had appeared once again and become infected. As for an infection of the



Fig 8 Total opacity of the right hemithorax. Four small shadows in the residual cavity of the left lung, July 15, 1940





Fig. 9

Fig. 9. Enlargement of roentgenogram, Figure 6.  
Fig. 9. Roentgenogram of May 3, 1920.



Fig. 10

Fig. 10. Enlargement of roentgenogram, Figure 1.  
May 10, 1920.



Fig. 11

adventitious membrane this would have caused both local and focal reactions together with repercussions of a varied degree on the general condition of the patient. It must be remembered, however, that the patient's condition had been excellent throughout the period of observation.

We have already stated that no daughter vesicles were found inside the cyst in the course of the first operation. Of this we can be certain because it is our practice always to carry out a thorough search and cleansing of the inner aspect of the cavity by means of the *peculiar procedure* that is by the use of a bivalve vaginal speculum. This instrument and the careful cleansing of the adventitia allow speedier healing whether the wound is sutured without drainage, as in this case, or the cyst cavity is marsupialized.

There is no doubt that in this instance and in spite of the thorough cleansing of the adventitia, some fertile scolices must have remained and become grafted in that closed pouch which lacked both a communication with the bronchial tree and outward drainage. This hypothesis is not affected by the presence of the postoperative fluid spotted in the residual cavity; this fluid may have been aseptic blood serum which was absorbed later on, thus allowing the scolices to develop inside the cavity. The hydatid cysts—resulting from the scolices—were seen to grow under roentgenographic observation, and once these vesicles have attained sufficient size to occupy the surface of the residual cavity their joint shadows appeared as a new hydatid cyst in this locality.



Fig. 12

Fig. 12. Roentgenogram of May 27, 1920.  
Fig. 13. Roentgenogram of June 2, 1920.



Fig. 13

Fig. 13. Enlargement of roentgenogram in Figure 1.  
July 5, 1920.



Fig. 14



Fig 15 September 8, 1941 The residual cavity has disappeared from the left lung and its place has been taken by an uneven shadow resembling that of a hydatid cyst.



Fig 16 A lateral x ray view shows that the cyst's shadow is not even The contour of the residual cavity is no longer visible, September 8, 1941

This explanation was confirmed at operation, for we found, not one hydatid with a mother germinative membrane containing daughter vesicles floating in the fluid but several isolated hydatids, in intimate contact with the adventitia.

The patient was again submitted to a preliminary pneumothorax which caused a partial collapse of the lung. We found that the lung had become adherent to the thoracic wall in the axillary region, a little behind the anterior thoracotomy, thus paving a road which allowed us to reach the cyst without opening the pleural space. This adherent zone corresponded exactly to the lung adhesion found at the first operation.

Under cyclopropane anesthesia, we resected a few centimeters of the posterior segment of the 4th rib—already affected by the first operation—and we came upon the zone of adhesions. After crystal clean fluid had been removed by means of an exploratory puncture, and, without having to cross any lung tissue, we made a superficial incision in the same area which opened a cavity the size of an orange. From this cavity some seven or eight hydatid vesicles were extracted, apart from those which were released by the incision and carried away by the fluid which came from the cavity while the first incision was being enlarged.

The vesicles shown in Figure 17 were removed from the adventitious pouch with the aid of an ordinary soup spoon, this instrument we have

always found most useful for the purpose of extracting any daughter cysts. The speculum procedure allowed us to remove the remains of other daughter vesicles, wipe out the remaining fluid with gauze swabs and finally to carry out a thorough cleansing of the cavity. In spite of the existing adhesions, we sutured the walls of the cyst to the edges of the incision in the thoracic soft parts, without including the skin. A rubber drainage tube, supported by gauze, and a few skin sutures to decrease the size of the incision completed the operation. Figure 18 shows the patient's left hemithorax after the third operation.

Some years previously, I had the chance of operating upon a woman patient who had a hydatid cyst of the right lung and another one of the liver. After insufflation of the right pleura (preliminary pneumothorax) and under a local anesthetic, I carried out a posterior thoracotomy through the 6th rib. A hydatid cyst of the inferior lobe was found—the contents were of a hyaline nature with no daughter vesicles—and it was treated according to Posadas' method (evacuation of the parasite and suture without drainage). After operation, x-ray films showed the appearance of fluid in the adventitious cavity. A year later, the liver cyst was treated with the same technique. But having found a suspicious shadow at the former level of the lung cyst operated upon, and under a general anesthetic with cyclopropane, we performed a new thoracotomy in order to

flash, a trail of fire into the ether bottle and a burst of flaming ether all through the room. It is the pattern for most accidents of this type. Frequently the machine has been started or stopped just before the flash but just as often there has been no prior manipulation of the switch.

In 57 of the 58 cases, the ignited anesthetic mixture has been ether-air. The other incident involved cyclopropane-air. No one was injured in 47 of the cases (46 ether-air and 1 cyclopropane air). In all 58 cases only 2 patients were affected, one was slightly and the second seriously burned about the head—surgeons, 1 nurse, and 4 anesthetists were seriously burned, 1 anesthetist and 5 surgeons slightly injured. This record is a striking tribute not to the safety of ether but to the retarding influence of air (approximately 79 per cent nitrogen—21 per cent oxygen) on the force and propagation of the pressure and flame waves of ether combustions with air as compared with ether-oxygen and ether-nitrous oxide-oxygen mixtures. The long period of toleration of this hazard has been due largely to this factor of relative harmlessness which is associated with the combustion of any anesthetic mixed with air.

This type of anesthetic fire or explosion is completely preventable today because of the progress in design and construction of suction and vaporizing machines. Inferior apparatus presents 5 possible sources of electrical sparks or arcs capable of igniting any combustible anesthetic mixture. These are (1) arcs produced at the make or break of the electrical circuit by the ordinary open switch (2) sparks produced by the revolving armature of the motor (3) sparks produced by the electrical current which may be induced in the metal shell of the cabinet by the operation of the motor (4) sparks produced by static electricity caused by the friction of parts of the apparatus within itself or against external objects. The induced electricity in item 3 or the static charge may spark in jumping the air gap to a grounded object or person (5) arcs produced by the make and, more often, the break of contact of the plug with the wall socket. This may be accidental as when the conducting cable is kicked, stepped on or drawn too taut.

Modern design and construction of suction and vaporizing apparatus and of electrical fixtures for use in operating rooms have provided the sure protection from this source of ignition which anesthetists and surgeons must demand for themselves and their patients in the hazardous circumstance of an anesthetic-laden room undoubtedly produced by insufflation anesthesia.

1 The open arcing switches are replaced by mercury switches. The opening and closing of the circuit is secured by the tilting of mercury in a glass tube in which are sealed the contact ends of the circuit.

2 The motor is sealed so that no contact is possible between the internal parts of the motor and the external atmosphere.

3 and 4. The metal shell or cabinet is freed of induced and static electricity by grounding. Grounding is automatic when the conducting cable of the machine is furnished with a three prong plug which fits into a triple contact socket containing a ground line built into the socket and wall during the installation of the electrical fixtures. If the wall socket is the conventional double contact type, made to receive only a two prong plug then the metal cabinet must be grounded by a dangle wire attached at one end to ground and at the other end to an unpaired part of the cabinet or to the third and unused prong of the three prong plug. The three prong plug may then be fitted to the double contact socket by means of a suitable adapter which provides a site for the connection of a ground wire to the "ground prong" of the three prong plug.

5 Arcing at the wall socket plug contact is to be avoided during the danger period by making the connection before the anesthesia is started and by not breaking the connection until the room is ventilated free of the combustible gases or gases. Furthermore, to prevent accidental breaking of the plug socket contact during the danger period, the plug socket connection should be of the locking type (6) The plug cannot be simply pulled out because it is inserted into the wall socket and locked there by partial turn or twist. Also, the wall outlet should be situated 4 or 5 feet above the floor to avoid the floor level at which the anesthetic most often used in vaporizing machines, namely ether tends to accumulate because of its heavy density.

These safety devices have long been available to hospital authorities. Ignorance of the hazards and lack of demand by anesthetists and surgeons have permitted the growth of the present dangerous situation wherein most insufflation anesthetics today are given in the presence of serious and obvious and preventable sources of ignition.

There is another method of securing a completely safe suction and vaporization and that is by the use of wall outlets connected by pipe lines to a remote centrally located source of suction and pressure. This arrangement is ideal in many respects however it is suitable only for installation in the process of construction or renovation

Many anesthetists have reported, after an accident or two, the adoption of inadequate methods of prevention such as buying another manufacturer's apparatus not of explosionproof type, or avoiding machines which suck ether into the compartment containing the motor, or discontinuing the practice of refilling the ether bottle while the motor is running. We know, however, that nothing short of the complete scheme of safeguards described here is entirely safe in the light of our present information.

The additional cost of such safety features as we have described is not prohibitive even for the small hospital. The extra expense is a permanent investment to be regarded as insurance against costlier injuries, property damage and malpractice claims. A plaintiff's lawyer would have a field day with a damage suit resulting from a fire or explosion ignited by a suction or vaporizing machine.

The approval of the Underwriters' Laboratories which is always sought in practically every other type of electrical apparatus, should always be demanded by hospitals and practitioners seeking to buy suction and vaporizing machines for use with anesthetic agents. There are many safe and approved models available through most of the manufacturers. This recommendation is in line with the authoritative editorial statement of Dr W E List, "In new constructions, the installation of explosionproof electrical equipment should be mandatory, and, whenever possible, hazardous fixtures should be replaced in old constructions."

We believe that it is the duty of the anesthetist to inspect the safeguards necessary for safe insufflation anesthesia and to insist on maintaining the very high standards of safety expected of all types of anesthesia. It is lopsided wisdom to follow strict antistatic precautions in the major operating rooms, while, in the "tonsil" room, one con-

tinues to expose a roomful of ether to a dangerous suction and pressure machine. With the few and simple safety measures described in this paper, we can prevent all anesthetic ignitions by this type of electrical apparatus and so eliminate about 25 per cent of all anesthetic explosions and fires. Indeed, the hazard and its prophylaxis have been officially recognized to the extent that a Canadian law was declared in effect on May 1, 1940, making it mandatory to use only those models of suction and vaporizing apparatus in the operating room which meet the standards of fireproofing and explosionproofing specified by the Ontario Hydroelectric Power Commission (4). These standards have been satisfied by the better types of machine offered by leading American manufacturers since 1932.

#### SUMMARY AND CONCLUSION

Fifty-eight cases of anesthetic explosions and fires ignited by an electrical spark originating in suction and vaporizing apparatus are reported.

The hazard has been analyzed and the five zones likely to contain sparking or arcing have been described.

The safeguards against these five dangerous zones have been described in detail.

We have reached the conclusion that this type of anesthetic fire and explosion is entirely preventable with the knowledge and apparatus available today.

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# GREENE HAZARDS OF FIRE AND EXPLOSION OF ANESTHETIC AGENTS 75

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## SLIDING HERNIA

LEO M. ZIMMERMAN, M.D., F.A.C.S., and HAROLD LAUFMAN, M.D.  
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SEVERAL years ago Bevan introduced his paper on sliding hernia with the statement that during an operation upon a hernia of this type he questioned his internes and assistants as to the anatomy and pathogenesis of sliding hernia and found that they had very little knowledge of the subject. He considered this a reason for his presentation of the matter. In virtue of his paper and the other excellent discussions which have appeared in recent years, our familiarity with the problem of sliding hernia no longer prevails. It is our impression, however, that the question of treatment with particular reference to the disposition of the sac, has been made unnecessarily difficult. The purpose of this presentation is to describe again the anatomical relations in sliding hernias and to advocate a return to the older and simpler method of dealing with the sac and its contents.

Sliding hernia, as the name implies, is a hernia in which some portion of retroperitoneal viscera is drawn down into the sac of an inguinal hernia. Two types have been described (Fig. 1). The more common variety is designated the parasaccular or partially extrasaccular variety. This type corresponds with that described by Moschowitz as a hernia produced by a "pulling mechanism." Because of the increasing size of an indi-

rect hernial sac, traction is made on the parietal peritoneum until some portion of retroperitoneal viscera, usually cecum or descending colon, is drawn into the sac. Under these circumstances, there is almost invariably a free fold of peritoneum comprising the anterior wall of the sac. The posterior wall, however, is made up of bowel with its partial peritoneal investment.

The second type which is statistically much less common, is the extrasaccular or sacless hernia. This corresponds to Moschowitz's hernia by "pushing mechanism." In hernias of this type, the viscera together with its peritoneal covering is pushed directly through the hernial orifice. It must be obvious that such herniation cannot occur in indirect hernias if the sacular explanation for the genesis of oblique inguinal hernia is to be accepted. It is possible, however, for such hernia to present through direct hernial orifices, and herniation of the bladder is not infrequent in this type of hernia.

The literature on the subject correctly emphasizes the possibilities of severe hemorrhage and of potential devitalization of the contained segment of large intestine if the sliding nature of the hernia is not recognized and if misguided attempts are made to dissect the bowel from the sac under the misconception that it is fixed by inflammatory adhesion. Such accidents have occurred. In order to obviate this danger various methods of dealing with the bowel and the sac have been devised. These fall into two main categories. The one most often recommended consists of attempts to paralyze the posterior wall of the bowel or to

From the Division of Surgery of Northwestern University Medical School and the Departments of Surgery of Michael Reese and Chicago Memorial Hospitals.

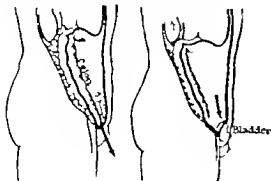


Fig. 1. Mechanism of sliding hernia. Left, Posteriorly placed structure is drawn into sac by pulling mechanism. Right, Pushing mechanism, which can affect only anteriorly placed structures such as bladder.

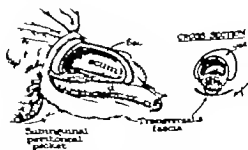


Fig. 2. Position of sac and bowel in sliding hernia. Spermatic cord and posterior wall of inguinal canal.

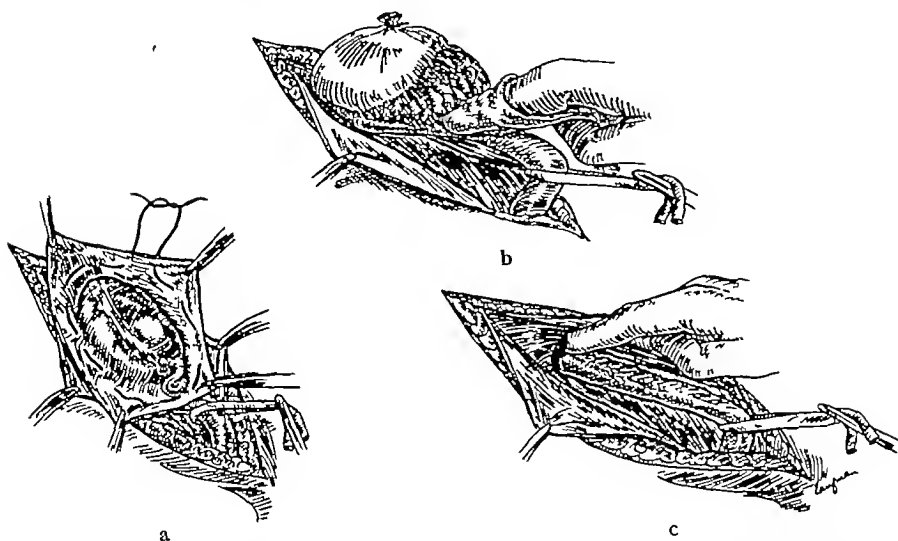


Fig 3 Disposition of sac and its contents in sliding hernia a, Pursestring closure of sac b, Dissection of sac and bowel from cord structures c, Reduction of sac through internal ring

create a mesentery from the peritoneal tissue of the sac. Such methods have been described by Hotchkiss, Walton, Bevan, and several earlier authors. The second method, originally propounded by Moschowitz, and more recently advised by Graham, consists of a free laparotomy incision with reduction of the colon from above and fixation to the posterior abdominal wall.

These methods are based upon the fear of injury to the mesenteric vessels coursing beneath the bowel which occupies the hernial sac. The illustrations which usually accompany such descriptions give the impression that these vessels retain their normal relationship to the areolar tissue over the iliopsoas muscles. This is an obvious fallacy. Once a viscus has entered a hernial sac, it has, perforce, left the abdominal cavity. As it emerges through the internal ring, it comes to lie upon the transversalis fascia together with the spermatic cord, as is the case in all indirect hernias (Fig 2). Such structures can be reduced from their adventitious position upon the floor of the inguinal canal with the same ease with which they reached it. In fact, such reduction is achieved incidentally in the various operations devised. There is no logic, once this has been attained, in attempting to create a mesentery or a posterior peritoneal investment for a portion of the colon which normally has no such serous layer. These procedures are time-consuming and are technically more or less difficult, and they serve no useful purpose. It is quite sufficient in hernias of this type merely to close the sac, reduce

it *en masse*, and repair the canal in the usual fashion.

#### TECHNIQUE

The sac in indirect inguinal hernia should always be opened high on its anterior surface, in order to avoid injury to the bowel if a sliding hernia should be present. This portion of the sac is almost invariably free and can be incised with safety. Once the sac is opened, the contents can be inspected and the true nature of the hernia determined. If colon forms a portion of the posterior wall of the sac as is the case in the ordinary sliding hernia, the following simple method of dealing with the sac and its contents is used. The reducible portions of the bowel are returned to the abdomen. A pursestring suture is then placed about the neck of the sac, extending as high on the anterior surface as possible and on the posterior side as close as is safe to the reflection of the peritoneum onto the colon. As this pursestring is pulled together, the bowel is turned upward and the sac is closed (Fig 3). The sac with its contained intestinal floor is very readily dissected from the cord structures in a manner comparable to that employed in nonsliding hernias. This dissection must be carried well into the abdominal ring, and the sac and bowel reduced into the abdominal cavity. Closure is then effected as in the ordinary hernia by suture of the transversalis fascia snugly about the cord to reconstruct the internal ring. Further repair can be done according to the practice of the operator. It is our practice merely to repair the internal ring by a few



## SLIDING HERNIA

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SEVERAL years ago Bevan<sup>1</sup> introduced his paper on sliding hernia with the statement that during an operation upon a hernia of this type, he questioned his internes and assistants as to the anatomy and pathogenesis of sliding hernia and found that they had very little knowledge of the subject. He considered this a reason for his presentation of the matter. By virtue of his paper and the other excellent discussions which have appeared in recent years, unfamiliarity with the problem of sliding hernia no longer prevails. It is our impression, however, that the question of treatment, with particular reference to the disposition of the sac, has been made unnecessarily difficult. The purpose of this presentation is to describe again the anatomical relations in sliding hernias and to advocate a return to the older and simpler method of dealing with the sac and its contents.

Sliding hernia, as the name implies, is a hernia in which some portion of retroperitoneal viscus is drawn down into the sac of an inguinal hernia. Two types have been described (Fig. 1). The more common variety is designated the parasaccular, partially extrasaccular variety. This type corresponds with that described by Moschcowitz<sup>2</sup> as a hernia produced by a "pulling mechanism." Because of the increasing size of an indi-

rect hernial sac, traction is made on the parietal peritoneum until some portion of retroperitoneal viscus, usually cecum or descending colon, is drawn into the sac. Under these circumstances, there is almost invariably a free fold of peritoneum comprising the anterior wall of the sac. The posterior wall, however, is made up of bowel with its partial peritoneal investment.

The second type, which is statistically much less common, is the extrasaccular or sackless hernia. This corresponds to Moschcowitz's hernia by "pushing mechanism." In hernias of this type, the viscus together with its peritoneal covering is pushed directly through the hernial orifice. It must be obvious that such herniation cannot occur in indirect hernias if the saccular explanation for the genesis of oblique inguinal hernia is to be accepted. It is possible, however, for such hernias to present through direct hernial orifices, and herniation of the bladder is not infrequent in this type of hernia.

The literature on the subject correctly emphasizes the possibilities of severe hemorrhage and of potential devitalization of the contained segment of large intestine if the sliding nature of the hernia is not recognized and if misguided attempts are made to dissect the bowel from the sac under the misconception that it is fixed by inflammatory adhesion. Such accidents have occurred. In order to obviate this danger, various methods of dealing with the bowel and the sac have been devised. These fall into two main categories. The one most often recommended consists of attempts to plicate the posterior wall of the bowel or to

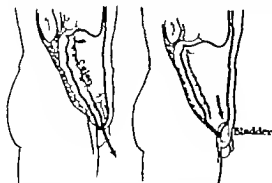


Fig. 1. Mechanism of sliding hernia. Left, Posteriorly placed structure is drawn into sac by pulling mechanism. Right, Pushing mechanism, which can affect only anteriorly placed structures such as bladder.

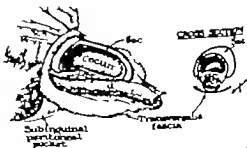


Fig. 2. Position of sac and bowel in sliding hernia with relation to spermatic cord and posterior wall of inguinal canal.



sutures of fine silk in the transversalis fascia which narrow this aperture to approximately its normal dimensions. The cord is then allowed to fall back into its normal position and the aponeurosis of the external oblique is reunited over it. However if one chooses to suture the internal oblique or the other layers of the abdominal wall, this can be done after complete reduction of the sac as in the usual forms of hernia.

Burdick and Highbotham have advocated division of the spermatic cord in hernias of this type, dropping the central end back into the peritoneal space and completely closing the canal. This is a worthwhile adjuvant in very large and very difficult hernias which involve the internal ring. It is not necessary however as a routine procedure in operations for sliding hernia.

It is frequently stated that the prognosis as to recurrence is much poorer in sliding hernias than in the ordinary variety. This has not been our experience. In a series of 24 cases of sliding hernia treated by the simple method described, there have been no known recurrences. Nor is there theoretical reason to expect more frequent failure than in other types of hernia. If anything the bulk of the reduced colon should produce some measure of protection against herniation by acting as a pad or buffer against the newly repaired internal ring.

The extrascapular or pushing hernia requires very little comment. As stated, this type of hernia is not to be expected in indirect sacs. It may occur, and unquestionably does, in a certain number of direct hernias, and the bladder is its most common occupant. Injury to this focus is easily avoided if the sac is reduced unopened. In direct hernias in general, it is either necessary nor desirable to open the sac. The sac in the ordinary types of direct hernia is usually broad blunt, and dome-shaped, and represents merely a bulge of peritoneum through a weakened inguinal floor. As a rule, these sacs are thick and opaque and contain a large amount of peritoneal fat. Mosch-

cowitz has pointed out that peritoneum is usually sparse except in the regions close to a reflection of peritoneum onto the viscera. The fatty appearance of direct hernial sacs should alert the operator of the proximity of the bladder.

Opening into such sacs serves no useful purpose and unnecessarily expends time and operative manipulation. The fatty opaque nature of the sacs demands the exercise of considerable time and care to avoid injury to the bladder if extrascapular or parascapular hernia is present. If the sac is isolated by dissection from the fibers of the transversalis fascia which course over it and is reduced unopened into the peritoneal space, the purposes of the operation are satisfied and risk of damage to the bladder is obviated. There remains but to suture the transversalis fascia over the defect and to re-enforce it by whatever method the operator deems adequate.

#### SUMMARY

The treatment of sliding hernia has been made unnecessarily difficult by the recent methods of dealing with the sac. These methods include laparotomy and reduction of the bowel from a bore, or the creation of a mesentery or a peritoneal diverticulum for the posterior surface of the bowel which lies in the sac. This peritonization serves no useful purpose and renders the operation unnecessarily complicated. The colon and its blood vessels occupy an abnormal position upon the transversalis fascial floor of the canal. From this site they can be readily restored to the abdominal cavity and the canal repaired in the usual fashion.

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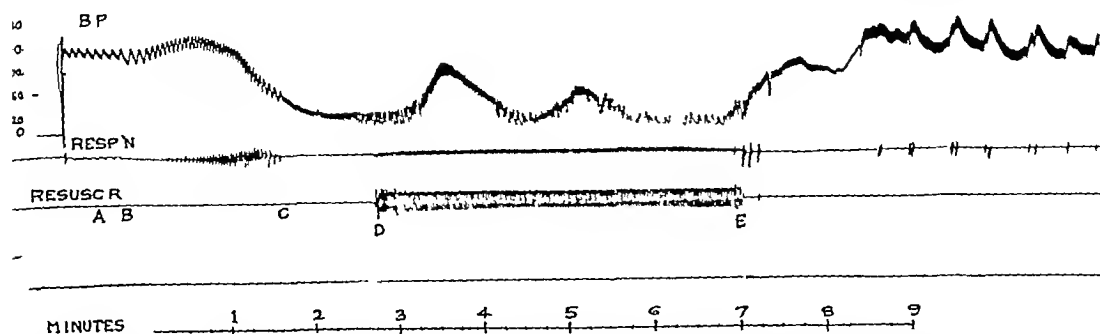


Fig 6 Dog 50. Altered and sluggish asphyxial resuscitation after double carotid sinus denervation. A, After carotid sinuses were denervated, B, asphyxia started by lamping tracheal tube—notice the initial period of apnea that follows and the sharp fall of blood pressure even be-

fore the respiration ceases, C, respiration ceases, D to E, resuscitator with nitrogen in action, E, blood pressure starts to rise and spontaneous respirations begin, the resuscitator is discontinued and the tracheal tube is opened to the atmosphere

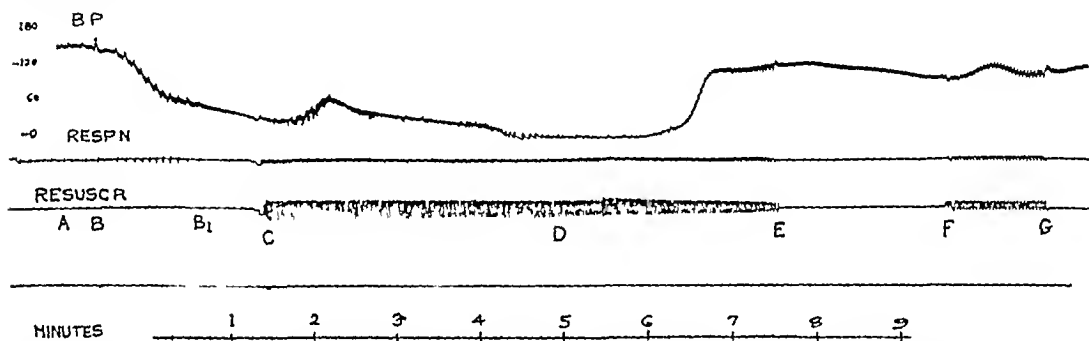


Fig 7 Dog 53. Failure of asphyxial resuscitation after double carotid sinus denervation. A, After denervation, B, through a leak proof intratracheal tube, nitrogen inhalation asphyxia has been started with an arrangement for "blow-off" of the expired air so as to prevent carbon dioxide accumulation. Notice the sharp fall of the blood

pressure even before the respiration ceases at B. C to D, Resuscitator with nitrogen fails to resuscitate, D to E, resuscitator with oxygen restores the circulation, E to F, trachea connected with oxygen, F to G, resuscitator with oxygen started again in an attempt to initiate spontaneous respiration

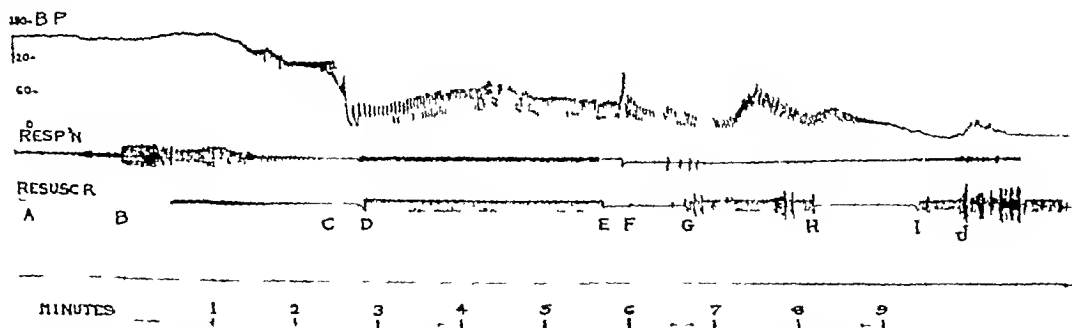


Fig 8 Dog 54. Failure of asphyxial resuscitation after double carotid sinus denervation. A, The carotid sinuses have been denervated. Notice the typical denervation effect, elevation of the blood pressure, small pulse pressure and rapid heart rate. B, nitrogen asphyxia started as for previous experiment. C, respiration ceases—notice the sharp fall of blood pressure following this, D to F, resuscitator

with nitrogen unsuccessful, E to G, tracheal tube connected to nitrogen. Although several spontaneous respirations were taken in the interval E to G, tracheal tube was not opened to atmosphere because blood pressure was very low. G to H, Resuscitator with nitrogen tried again, H, tracheal tube opened to atmospheric air, I, resuscitator with oxygen, plus "external heart massage," unsuccessful

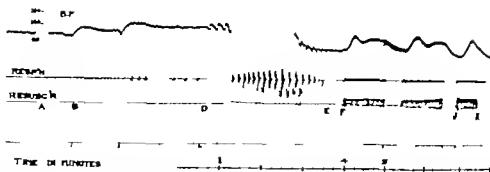


Fig 3 Dog 30. Failure of apyria resuscitation after double vagotomy. A, Control, before vagotomy; B left vagus is cut in the mid neck; C, right vagus cut in the mid-neck; D apyria begun by clamping intratracheal tube; E, respiration ceases; F to G resuscitator with nitrogen

applied; G to H tracheal tube connected to atmosphere; H to I and J to K resuscitator. Nitrogen was used but the blood pressure could not be maintained and spontaneous respirations did not occur. J following the tracheal was resuscitated. Nitrogen (not shown).



Fig 4 Dog 41. Altered and atypical apyria resuscitation after double carotid sinus denervation. A, After carotid sinuses are denervated; B apyria started by clamping tracheal tube; C, respiration ceases; D to E, resuscitator with nitrogen in action; E to F trachea con-

ected to nitrogen only; F to G, resuscitator, all others was again brought in action; G to H trachea, reconnected to nitrogen only; H spontaneous respirations effected, and tracheal tube opened to the atmosphere; I.

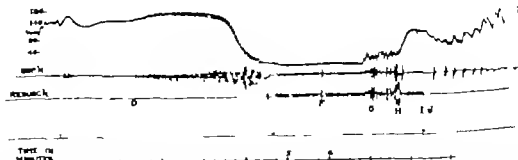


Fig 5 Dog 4. Continuation of previous experiment. A, Control; B left vagus as cut in mid neck; C right vagus as cut; D apyria was started by clamping tracheal tube. Notice the precipitous fall of the blood pressure even before respiration ceased; E to F Resuscitator with nitrogen as unsuccessful in effecting resusci-

tation; F to G, resuscitator with oxygen as in action, the heart ceased; G to H, bile resuscitator as in action, the heart was managed, with the chest closed, by bilateral sternotomy compression close to the sternum; I resuscitator as continued and tracheal tube opened to the air; J spontaneous respiration brought.

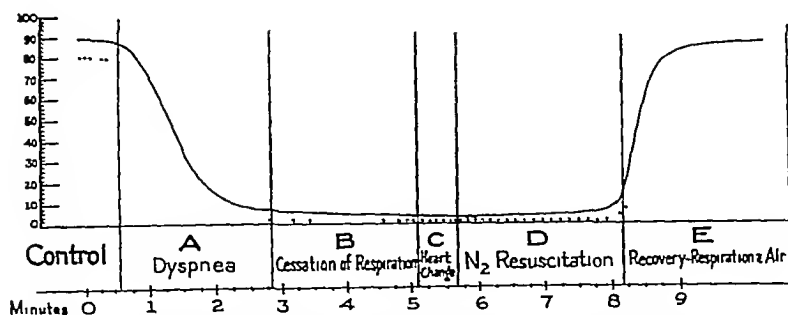


Fig 11 Composite graphs of oxygen saturation of the blood at various stages of obstructive asphyxia. Solid line, arterial blood from femoral artery, dotted line, venous blood from jugular vein. Vertical scale on left indicates percentage saturation of the blood with oxygen. Asphyxia starts after control period A, Period of dyspnea, B, period of cessation of respiration—secondary apnea, C, “critical period” of the heart, the sign of impending failure, D, period during which suck and blow resuscitation with nitrogen is in action, E, period of recovery. The blood pressure had already risen and the heart beat recovered toward the end of the previous period, D. At the start of period E, spontaneous respiration having occurred, the tracheal tube is left open to the atmospheric air.

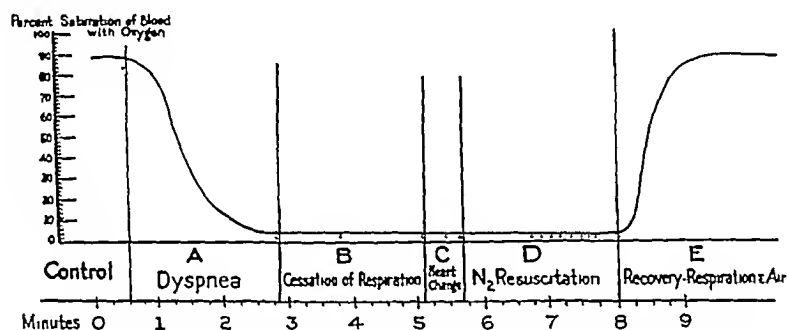


Fig 12 Composite graphs of oxygen saturation of the blood at various stages of nitrogen inhalation asphyxia. Description of this graph same as for Figure 11.

blood is already at an extremely low level (Figs 11 and 12).

Blood gas analyses also show a high oxygen unsaturation (low oxygen content) at the institution of asphyxial resuscitation, at later periods of the procedure, the unsaturation may increase slightly and this could indicate utilization of oxygen by such vital organs as the heart and brain. Some of the oxygen in the pulmonary capillaries could also be washed out into the alveoli and aspirated into the resuscitator. The oxygen in the blood vessels is the first available, but mobilization of oxygen from capillary pools<sup>1</sup> and the tissues is a possibility to consider. The washing out of carbon dioxide from the blood into the alveoli and re-

suscitator, by lessening medullary depression, may also be a factor in sustaining and prolonging life.<sup>2</sup>

#### SUMMARY

We have seen that advanced states of asphyxia were produced in our experiments by obstruction of the trachea or by inhalation of inert—asphyxiating—gases such as nitrogen or helium. If the asphyxiating procedure is not stopped within 20 to 30 seconds after the cessation of respiration, spontaneous recovery usually does not occur. However, if within periods of 45 seconds to 2½ minutes after cessation of respiration suck and blow resuscitation with inert—asphyxiating—gas is applied, resuscitation of the circulation and respiration can be accomplished in 85 per cent of instances. The addition of 10 per cent carbon di-

<sup>1</sup>We have found regular evidence of shock in asphyxiated animals: serous peritoneal exudate, edema of the intestines, capillary dilation in the liver and spleen, arterial constriction and venous dilation in the mesentery of the intestine. It is known that in shock capillary dilation, stagnation of blood and tissue edema occur.

<sup>2</sup>Alveolar and blood gas analyses for oxygen and carbon dioxide and the question of oxygen mobilization is the subject of a paper to follow.

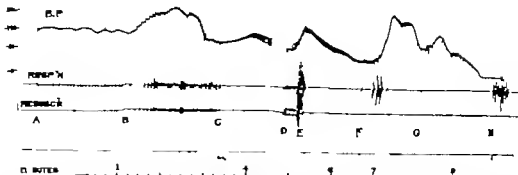


Fig. 9. Dog 58. Failure of asphyxial resuscitation after double carotid nerve denervation. A. Carotid sinuses have been denervated. B. Nitrogen asphyxia is started. C. Respiration ceases. D to E. Resuscitator with nitrogen in action. E.

spontaneous respirations are taken and the tracheal intubation is opened to the atmosphere. At F and G further spontaneous respirations are taken but circulation fails to return. At H agonal respirations are taken and death follows.

stance depressing to the medullary centers in the presence of asphyxia.

4. A reflex mechanism to the medullary centers, by way of the vagus or other nerves, concerned with circulation and respiration.

5. A combination of two or more of the above.

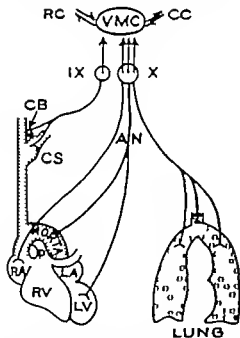


Fig. 10. Regulation of circulation and respiration. Scheme of afferent impulses to the medullary centers by way of the carotid sinus nerves and the cardioaortic and aortic nerves. RC, Respiratory center; CC, cardiac center; VMC, vasomotor center; IX, glossopharyngeal nerve; X, vagus nerve; CB, carotid body; CS, carotid sinus; AN, aortic nerve; CC, common carotid artery.

Bilateral vagus section in the neck prevents resuscitation with inert gas (Figs. 2, 3 and 5). Carotid sinus denervation may (Figs. 7 & 8) or may not (Figs. 4 and 6) prevent resuscitation. It is evident, therefore, that the phenomena is primarily a reflex mechanism (hypothesis 4) in which the vagus (cardioaortic, pulmonary fibers or both) is indispensable. The carotid sinus nerve is vitally concerned but not absolutely indispensable in asphyxial resuscitation. Its role, therefore, may be that of a most important regulator which impales to the medullary centers. It is as if the elevation of blood pressure, which is initiated reflexly through the afferent fibers in the vagus, may require the accessory regulatory stimulus of the carotid sinus nerve to maintain such elevation.

We have seen above that with nitrogen resuscitation the circulation recovers regularly before spontaneous respiration begins. Three hypotheses present themselves:

1. The afferent reflex impulses go first to the cardiac or vasomotor center or both and indirectly to the respiratory center which is at first refractory.

2. The nerve impulses first reach the respiratory center which as yet does not respond, and irradiate to the cardiovascular centers.

3. The impulses reach the centers simultaneously, the respiratory center being refractory at the start.

Once the circulation is more or less definitely re-established by rock and blow resuscitation with inert gas, the animal may be kept alive for 1, 2, 3 or more minutes longer, as the case may be, if the procedure is persisted in instead of the use of the resuscitator being discontinued. This is quite remarkable since when the respiration ceases in asphyxia, the oxygen saturation of the

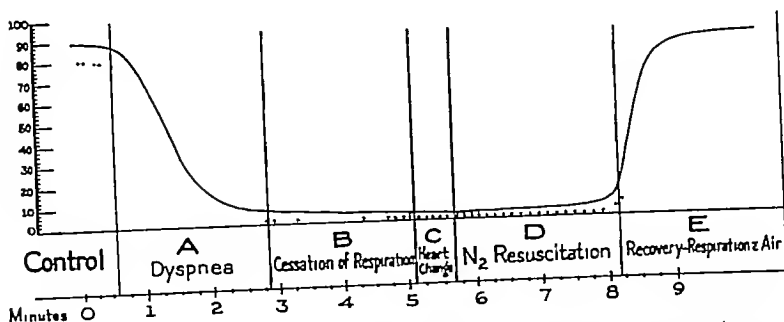


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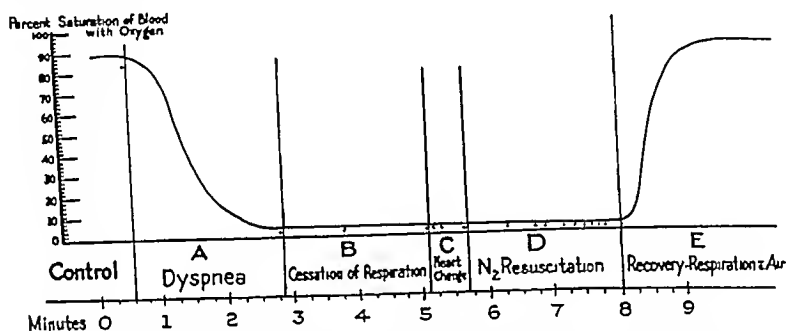


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<sup>2</sup>Alveolar and blood gas analyses for oxygen and carbon dioxide and the question of oxygen mobilization is the subject of a paper to follow.



oxide to the inert gas inhibits resuscitation. Bilateral vagus section before asphyxia is started prevents asphyxial resuscitation with inert gas. The carotid sinuses are also greatly concerned in this phenomenon. Carotid sinus denervation carried out before obstructive asphyxia gives an altered and sluggish asphyxial resuscitation. Denervation before nitrogen inhalation asphyxia prevents asphyxial resuscitation.

Asphyxial resuscitation is primarily a reflex phenomenon which is initiated most efficiently by suck and blow resuscitation within safe limits of pressure. Thus, resuscitation with inert gas can be accomplished by suck and blow (16-20 strokes per minute, with plus 14 mm. Hg., minus 9 mm. Hg.) in 85 per cent of instances. On the other hand, resuscitation with inert gas can be accomplished in only 15 to 20 per cent of instances by one of the following methods: manual artificial respiration with nitrogen inhalation, rhythmic pressure with nitrogen at plus 12 to 14 millimeters of mercury or rhythmic suction on the lung at 8 to 1 millimeters of mercury alternating with nitrogen inhalation. These facts would indicate that asphyxial resuscitation is primarily a reflex from the vagus endings in the lungs to the medullary centers. Moreover, the greater rhythmicity and adequate combined inflation and active deflation of the lung by the suck and blow resuscitator appears more effectively to stimulate the pulmonary vagal endings.

#### CONCLUSIONS

1. A powerful reflex mechanism allows resuscitation with rhythmic pressure and suction on the lungs to take place with the use of only inert gas and not oxygen.

2. The mechanism of this phenomenon has been analyzed.

3. Clinically in advanced asphyxia when the respiration has ceased, advantage should be taken of this phenomenon by the administration of oxygen or oxygen-carbon dioxide by the suck and blow type of resuscitation, within safe limits of pressure.

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# THE USE OF ESTRADIOL DIPROPIONATE IN THE TREATMENT OF ESSENTIAL DYSMENORRHEA

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Boston, Massachusetts

**I**N a previous paper discussing estrin therapy for essential dysmenorrhea (2), it was pointed out that the dramatic and complete relief from cramps that can be produced by estradiol benzoate was associated with an unexpected change in ovarian function. From evidence obtained by endometrial biopsy, it was demonstrated that a cramp-free period followed such therapy only when the formation of a secretory endometrium was prevented, apparently due to the suppression of ovulation. Later work showed that this result could be obtained as well with oral stilbestrol (1), when given according to certain specifications, as with estradiol benzoate. The purpose of the present paper is to confirm these previous observations by reporting the results with a third estrogen—estradiol dipropionate, and to emphasize certain principles that are equally important in the treatment of dysmenorrhea with any potent estrogenic compound.

If an adequate dose of estrogen is given early enough in the menstrual cycle and continued over a sufficient length of time, not only will it prevent the formation of a secretory endometrium, but it will produce an endometrial proliferation from which bleeding occurs when the estrogen is withdrawn. It seems probable that the first effect is due to an inhibition of the follicle-stimulating hormone by estrogen, thereby preventing the maturation of the young ovarian follicle so that ovulation that month cannot occur. This transient suppression of ovulation explains the absence of a secretory endometrium after treatment. The second effect—that of bleeding following withdrawal of estrogen—is unaccompanied by any pain whatsoever for reasons so far unexplained. If estrogen is given too late in the cycle, however, when the graafian follicle is no longer dependent on a growth stimulus from follicle stimulating hormone, then therapy is ineffective in prevention of ovulation and the cramps in that case will not be completely eliminated.

It has been found that the effective dose of estradiol benzoate (progynon-B), to obtain these results consistently was 6 injections of 1.66 milli-

grams subcutaneously, started on or before the 6th day of the cycle and repeated every 3d day. The disadvantages of this treatment are that it is expensive and that 6 hypodermic injections of this dose appear to be necessary. Oral stilbestrol is a more convenient and less expensive type of estrogen therapy. Consistent results are generally obtained with a dose of 1 milligram daily for 20 days, started on the 2d or 3d day of the cycle. Since about 20 per cent of patients given stilbestrol are likely to have gastrointestinal symptoms of varying intensity, this preparation is not, however, ideal.

## RESULTS

In the last year and a half, 33 patients with essential dysmenorrhea have received over 260 injections of estradiol dipropionate (diovocylin). No nausea or other toxic effects that could be ascribed to this medication were encountered. Treatment was given primarily to afford clinical relief from monthly pain, secondly, it was hoped to determine the exact timing of injections that could be given to cause painless estrin-withdrawal bleeding at approximately monthly intervals. A large majority of the injections were successful in eliminating cramps during the month or more of treatment, a statistical analysis, however, of the successes and failures does not yield pertinent details of response. Thus, there were approximately 130 menses following treatment and of these 88, or 68 per cent, were completely painless. However, in 11 per cent the pain, though better, was not entirely eliminated, and in 27, or 20 per cent, the cramps were as severe as when no medication was given. But some of these painful periods were delayed and did not occur for an interval of 4 or more weeks after the end of the injections. Such an interval suggests that a complete ovulatory cycle might have occurred after treatment, such a result cannot be properly included in the "failures." These complications make it difficult to present a clear statistical analysis and suggest the desirability of presenting a discussion of typical examples of various responses rather than a table of figures.<sup>1</sup>

<sup>1</sup>Presented at the Massachusetts General Hospital during the Clinical Congress of the American College of Surgeons, Boston, November 7, 1941.

Below are discussed and graphically illustrated examples of the following: (1) Failure to respond to treatment due either to an inadequate dose or to starting medication too late in the cycle or both; (2) typical response after an adequate dose started early enough in the cycle; (3) the timing of adequate doses to produce consecutive anovulatory flows at approximately monthly intervals; (4) further evidence that elimination of cramps after estrogen is associated with suppression of ovulation.

1. *Failure to respond to treatment due to either an inadequate dose or starting medication too late in the cycle or both.* In previous experience with dosage of estradiol benzoate it was shown that an adequate amount of this estrogen must be started at least by the 6th day of a 28 day cycle to prevent ovulation. On this basis we first tried an injection of 5 milligrams of estradiol dipropionate on the 6th day and repeated it 10 days later. It was found that this dose and timing did not give consistently satisfactory results. Either ovulation was not consistently suppressed or else the endometrium was not always sufficiently stimulated to break down later into withdrawal bleeding (see Charts 1 and 2). Therefore in all but 23 of the 260 injections, 10 milligrams was used. It is recognized that this may prove to be more than the minimum necessary to obtain the desired ends; the use of large doses, however, gave consistently predictable results.

*Typical response after an adequate dose started early enough in the cycle.* If a single dose of 10 milligrams of estradiol dipropionate is given within the first 6 days of a cycle, a painless withdrawal flow generally will follow in about weeks (Chart 3). This is longer than the interval to bleeding after estradiol benzoate, when a total of 10 milligrams of the benzoate is given, bleeding usually occurs in from 4 to 10 days, the average being 8 days (1). The interval from a single injection to withdrawal bleeding varies however from individual to individual. In the present series this withdrawal interval varied from 10 to 17 days, with the mean at 13 days (see Chart 3). One might predict that it should be possible to maintain the endometrium almost indefinitely by repeated injections at short intervals if our assumption of the suppression of ovulation is correct. One should be able to produce an amenorrhea of an desired duration by starting an injection of 10 milligrams early in the cycle and repeating it, say every 10 days—before an estrogen withdrawal breakdown of the endometrium can occur. Conversely if estrogen when given early does not suppress ovulation, then one could confidently

predict that menstruation will occur when the corpus luteum atrophies and progesterone is withdrawn irrespective of concurrent estrogen medication. In the present series there is some evidence that bleeding could be postponed at 10 days by giving 10 milligrams early in the cycle and repeating the dose before withdrawal bleeding takes place (Chart 4). This can be interpreted only on the basis that ovulation has been suppressed and the pituitary-ovarian cycle held in abeyance until such estrogen therapy is stopped. It is not, however, ideal to produce a period of amenorrhea of 6 or more weeks by repeated injections at short intervals since the endometrium will become so hyperplastic that a profuse or prolonged flow generally follows the cessation of such treatment (Chart 4).

In order to prevent the endometrial hyperplasia that results from repeated stimulation without interruption, the endometrium may be allowed to break down and bleed after each injection before the dose is repeated. It is thus often possible to produce anovulatory periods twice a month for several months by repeating the injection on the first day of each episode of withdrawal bleeding (Chart 5). Unfortunately however this simple plan of treatment cannot consistently be counted upon because of the variability of the withdrawal interval noted in Chart 3. It is well to emphasize once more that the effects result from withdrawal of estrogen—after the dose has ended, the visible effect is onset of bleeding generally in from 4 to 7 days; the invisible effect is release of the pituitary to produce gonadotropin. The interval to bleeding has already been tabulated, but we have no data on the interval to pituitary release. There is no reason to believe that the two effects are necessarily synchronous. From a study of our cases it is apparent that an interval of more than 14 days between injections may be sufficient for the pituitary to escape from estrogen-repression, follicle-stimulating hormone is then produced, a follicle started, and the second dose may be useless to prevent ovulation. It should be clear therefore that if repetition of the dose is always delayed until onset of withdrawal bleeding, and if the latter should not occur for 16 or 17 days (see Chart 3) then such an interval may allow a follicle to develop to a point no longer vulnerable to further follicle stimulating hormone repression. For example even if in Chart 3 a dose of 10 milligrams had been given at the onset of the withdrawal bleeding that occurred after a 16 day withdrawal interval, it might still have had no effect on ovulation that probably occurred 4 or 5 days later.

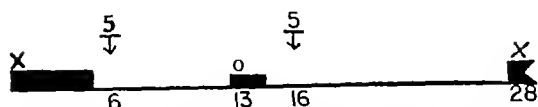


Chart 1<sup>1</sup> MGH—EG This patient had noted a little bleeding in 3 out of the 6 previous months at intervals of 13, 15, and 15 days from onset of menses. These episodes of spotting just 2 weeks before the next menses are believed to have been associated with the occurrence of ovulation at that time during those months. In this chart it is probable that the painless flow represented by O on the 13th day was again associated with ovulation since it occurred 15 days before the onset of a typical crampy period. The dose of 5 milligrams on the 6th and again on the 16th days appears in this case to have had no effect on the ovarian cycle.

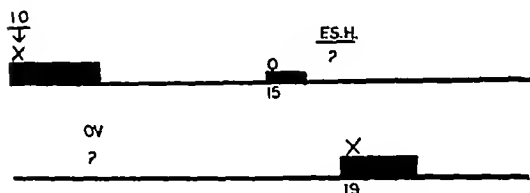


Chart 3 J V M—S B A single dose of 10 milligrams given on the first day of the cycle in this case produced a characteristic painless and scanty flow after a "withdrawal interval" of 14 days (see O). The next menses with cramps occurred 32 days after this withdrawal bleeding, a total of 46 days from the single injection. One can postulate that ovulation probably occurred about the 5th day of the second month (see ? OV), following release of gonadotropin from the pituitary about 2 weeks previously (see ? FSH). The scanty flow at O in this case cannot be explained on the basis of a little spilling over at time of ovulation (see Chart 1) since in that case the crampy menses would have occurred 2 weeks later instead of in 32 days.

There are, therefore, two disadvantages to the use of a "rule-of-thumb" that the dose may be repeated indefinitely on the first day of withdrawal bleeding. First, although if successful the "periods" are painless, yet it is a nuisance to the patient to have bleeding every 2 weeks. Second, if the interval to bleeding should be more than 2 weeks, there is a distinct possibility that the second injection will be too late to be effective.

3. *Timing injections to produce consecutive anovulatory flows at approximately monthly intervals.* Since it is neither ideal to give a long series of injections producing endometrial hyperplasia (Chart 4) nor to withhold the next injection until onset of bleeding we have tried to plan a compromise schedule of timing injections. The ideal timing of repeated injections over several consecutive months would have to keep the pituitary constantly repressed, yet allow painless endomet-

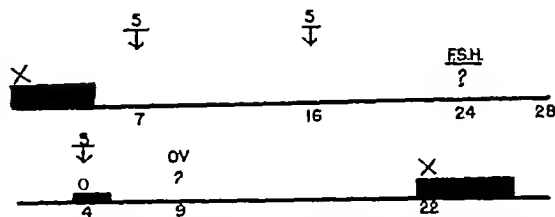


Chart 2 MGH—VF In this chart, a slight spotting without pain, O, occurred 16 days after the second dose of 5 milligrams. A third dose of 5 milligrams on the day this spotting appeared did not prevent cramps during the flow 18 days later. It may be postulated that the first 2 doses repressed the pituitary until about the 24th day—(see ? FSH). Follicular development, started about that time, progressed too far to be affected by the third dose and probably resulted in ovulation on about the 9th day of the 2d month (? OV) and dysmenorrhea 2 weeks thereafter. The scantiness of the withdrawal bleeding induced by 2 doses of 5 milligrams indicates that this amount of medication provides a minimum proliferative stimulus to the endometrium.

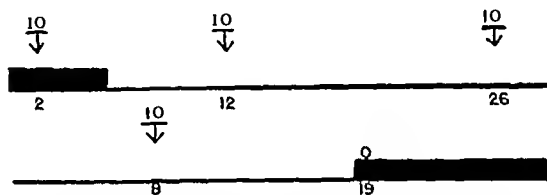


Chart 4 J V M—R P A dose of 10 milligrams given on the 2d day of the cycle was repeated three times without the occurrence of withdrawal bleeding until 11 days after the last injection. The flow that then occurred was painless, but prolonged and profuse due to breakdown of a hyperplastic endometrium. The 4 injections here produced an amenorrhea of 47 days. This could have been prolonged almost indefinitely by maintaining the endometrium with repeated doses at short intervals, but the bleeding that would have eventually followed the last dose would have been undesirably profuse.

rial breakdown to occur at approximately monthly intervals. This can generally be done by following a definite schedule (Chart 6). The first injection in such a scheme must be given by the 6th day after onset of menstruation, the second 10 days later, and the third 2 weeks later. In this 2 week interval, withdrawal bleeding is likely to occur. If there is no bleeding in this time, however, injections are nevertheless continued according to plan. Thereafter, the injections are given 10 days, 10 days, and 14 days apart, and this timing of 3 injections may be repeated yet again. This plan of therapy with estradiol dipropionate, then, necessitates only 2 or 3 injections a month, a distinct advantage over the 6 injection treatment found necessary in the use of the benzoate ester in the handling of these cases. When estrogen stimulation of the endometrium is consecu-

<sup>1</sup>In each chart each line represents 8 days. indicates absence of cramps; dose in milligrams of estradiol dipropionate indicated by arrows.

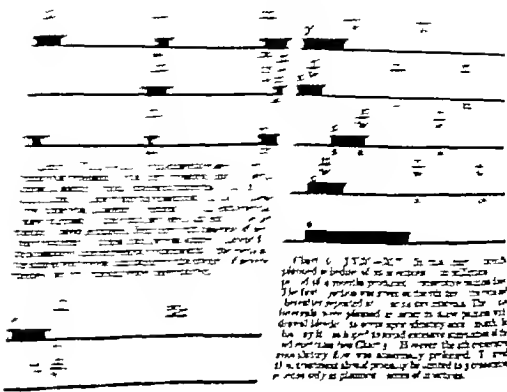


Figure 1. J.T.C.-X. In the top view  
 showing a section of the cylinder. The  
 piston is shown in the center. The  
 crankshaft is shown below the piston.  
 The first part of the drawing shows the  
 crankshaft in the center. The second  
 part shows the piston in the center.  
 The third part shows the crankshaft  
 in the center. The fourth part shows  
 the piston in the center. The fifth  
 part shows the crankshaft in the center.  
 The sixth part shows the piston in the center.  
 The seventh part shows the crankshaft  
 in the center. The eighth part shows  
 the piston in the center. The ninth  
 part shows the crankshaft in the center.  
 The tenth part shows the piston in the center.  
 The eleventh part shows the crankshaft  
 in the center. The twelfth part shows  
 the piston in the center. The thirteenth  
 part shows the crankshaft in the center.  
 The fourteenth part shows the piston in the center.  
 The fifteenth part shows the crankshaft  
 in the center. The sixteenth part shows  
 the piston in the center. The seventeenth  
 part shows the crankshaft in the center.  
 The eighteenth part shows the piston in the center.  
 The nineteenth part shows the crankshaft  
 in the center. The twentieth part shows  
 the piston in the center. The twenty-first  
 part shows the crankshaft in the center.  
 The twenty-second part shows the piston in the center.  
 The twenty-third part shows the crankshaft  
 in the center. The twenty-fourth part shows  
 the piston in the center. The twenty-fifth  
 part shows the crankshaft in the center.  
 The twenty-sixth part shows the piston in the center.  
 The twenty-seventh part shows the crankshaft  
 in the center. The twenty-eighth part shows  
 the piston in the center. The twenty-ninth  
 part shows the crankshaft in the center.  
 The thirtieth part shows the piston in the center.  
 The thirty-first part shows the crankshaft  
 in the center. The thirty-second part shows  
 the piston in the center. The thirty-third  
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 The thirty-fourth part shows the piston in the center.  
 The thirty-fifth part shows the crankshaft  
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 The thirty-eighth part shows the piston in the center.  
 The thirty-ninth part shows the crankshaft  
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 the piston in the center. The forty-first  
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 The forty-second part shows the piston in the center.  
 The forty-third part shows the crankshaft  
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 The forty-sixth part shows the piston in the center.  
 The forty-seventh part shows the crankshaft  
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 The fiftieth part shows the piston in the center.  
 The fifty-first part shows the crankshaft  
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 part shows the crankshaft in the center.  
 The fifty-fourth part shows the piston in the center.  
 The fifty-fifth part shows the crankshaft  
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 part shows the crankshaft in the center.  
 The fifty-eighth part shows the piston in the center.  
 The fifty-ninth part shows the crankshaft  
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 part shows the crankshaft in the center.  
 The sixty-second part shows the piston in the center.  
 The sixty-third part shows the crankshaft  
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 The eighty-second part shows the piston in the center.  
 The eighty-third part shows the crankshaft  
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 The eighty-sixth part shows the piston in the center.  
 The eighty-seventh part shows the crankshaft  
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 the piston in the center. The eighty-ninth  
 part shows the crankshaft in the center.  
 The ninetieth part shows the piston in the center.  
 The ninety-first part shows the crankshaft  
 in the center. The ninety-second part shows  
 the piston in the center. The ninety-third  
 part shows the crankshaft in the center.  
 The ninety-fourth part shows the piston in the center.  
 The ninety-fifth part shows the crankshaft  
 in the center. The ninety-sixth part shows  
 the piston in the center. The ninety-seventh  
 part shows the crankshaft in the center.  
 The ninety-eighth part shows the piston in the center.  
 The ninety-ninth part shows the crankshaft  
 in the center. The one hundred part shows  
 the piston in the center.

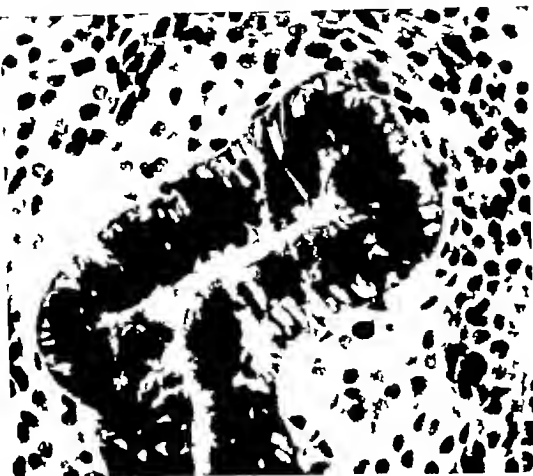


Fig 1 J V M—M G Endometrial biopsy taken on the 34th day of the cycle, 28 days after an injection of 10 milligrams of estradiol dipropionate in a patient with previously regular painful menses. The epithelial glands show central nuclei, subnuclear vacuoles. The stroma is edematous. This biopsy shows changes that occur very soon after ovulation, the early effect of the corpus luteum hormone.

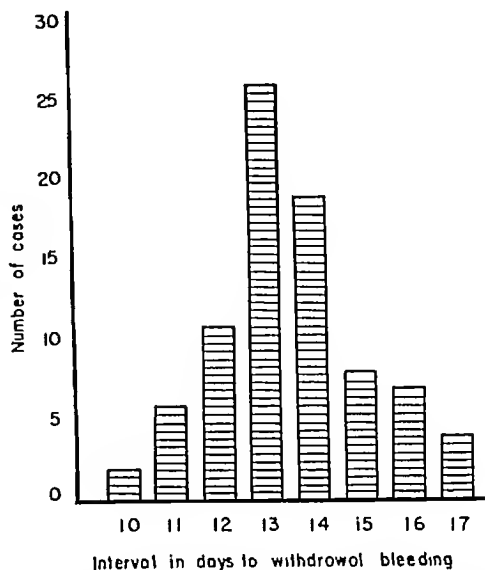


Chart 8 In 88 cases the number of days after an injection of 10 milligrams of estradiol dipropionate to onset of painless withdrawal bleeding varied from 10 to 17 with the mean for the group at 13 days.

usual secretory pattern may have been overwhelmed or otherwise repressed by the large dosage of estrogen employed, and that absence of secretion in the endometrium cannot constitute proof of the suppression of ovulation.

The results of treatment in the present series, however, bring out other effects for which we can conceive of no other rational explanation than that ovulation has been suppressed by the estrogen given.

The first additional evidence for the thesis that ovulation is suppressed was discussed in the second preceding paragraph. Here it was reasoned that the ability to produce an amenorrhea of any desired duration with repetition of the dose of estrogen here used could be explained only on the basis of temporary repression of follicular development.

Second, attention may again be called to an effect noted in the previous paper on the use of stilbestrol in essential dysmenorrhea (1). It was pointed out that these patients as a group showed unusually regular cycles before treatment. They were given 2 to 3 weeks of medication. Painless bleeding generally occurred 1 week later, but in 24 per cent of that series, no such bleeding appeared and instead there was an interval of over 1 month of amenorrhea after the last dose, terminated by menses with typical cramps. It seems illogical to suppose that this amenorrhea totalling 6 to 7

weeks, in patients previously regular, should occur on the basis of a chance irregularity alone as often as 24 per cent of the times treatment was given. Some other explanation than mere coincidence appears necessary. Many other patients showed only a scant spotting a week after the last medication, but it is significant that a crampy menses invariably occurred in the whole group about 1 month after treatment was concluded. The constant occurrence of this monthly interval, consistent with the individual's regular cycle, lends support to our contention that the normal pituitary-ovarian cycle is repressed until cessation of the estrogen. It is then easily understood that variability in the amount of painless bleeding directly after treatment—from none at all to slight menorrhagia—is merely a measure of the response of the individual endometrium to the character of stimulation given.

Similar reasoning can be applied to the variation in the amount of bleeding after estradiol dipropionate (occasionally there was no bleeding at all directly after treatment, at other times it varied from a scant spotting to a rather profuse flow). A consistent interval, however, from the last injection to the next crampy flow almost invariably obtains, whether or not a painless "withdrawal bleeding" occurs in the meantime. This interval is longer than the patient's usual cycle length. It is prolonged by the amount of

time that the last injection effectively inhibits the pituitary. In the present series the interval from an injection of 10 milligrams to the next typical dysmenorrhea, if no more medication was given, varied from individual to individual with a range of from 36 to 46 days for the group (Chart 2).

One case in the present series deserves special mention. In a 26 year old girl with regular painful periods, one injection of 10 milligrams of the dipropionate was given on the 6th day of the cycle. On the 34th day of the same cycle, when the patient was approximately 1 week overdue endometrial biopsy and laparotomy were performed. The endometrium was early secretory in type showing well marked subnuclear vacuoles in the epithelial glands (Fig. 1). Fresh blood was found in the pelvis and a very recent corpus hemorrhagicum demonstrated in an ovary. These findings strongly suggest that ovulation had occurred not more than 2 or 3 days previous to the operation on the 34th day (Chart 7). They confirm the postulates here presented to explain the cases of 5 or 6 weeks' amenorrhea not infrequently encountered, and constitute incontrovertible evidence that in this case the injection of estrogen delayed or temporarily suppressed ovulation.

In view of the facts presented, we believe that sufficient evidence has been accumulated to conclude that if an adequate dose of estrogen is given early enough in the cycle ovulation will be temporarily suppressed the true ovarian cycle will not start until the effect of the dose has worn out and released the pituitary to produce follicle stimulating hormone. Then, and not until then will a follicle develop to maturity and finally ovulate, and the result in these patients will be the return of typical dysmenorrhea consistently about 1 month after pituitary release.

#### SUMMARY

Previous work on the treatment of essential dysmenorrhea with estradiol benzoate and stilbestrol is summarized. The results of over 360 injections of estradiol dipropionate in 33 patients with this complaint are discussed in the light

of the previous experience. Examples of chart and actual case records are presented to demonstrate not only successful treatment, but also the path of this type of therapy. The previous contention that cramps are eliminated temporarily by suppression of ovulation is supported by further evidence from the present series.

#### CONCLUSION

1. The cramps of essential dysmenorrhea can be successfully eliminated with estrogen when an adequate dose is started early enough in the cycle to suppress the pituitary hence ovulation. The suppression is maintained until the effect of a given dose has worn off. After conclusion of treatment a normal cycle invariably recurs at the usual dysmenorrhea.

2. This effect can be obtained as well with estradiol dipropionate as with estradiol benzoate or oral stilbestrol. The advantages of using the former are that a minimum of injections are required and there are no demonstrable toxic effects.

3. To obtain the desired result with estradiol dipropionate an injection of 10 milligrams must be started by the 6th day after onset of menses. This dose is repeated in groups of 3 injections at 10 day intervals, except that every third injection should be given after a 14 day interval to allow a painless withdrawal bleeding to take place approximately once a month.

4. Estrogenic treatment according to the schedule given should probably be limited to 3 consecutive months, a painful ovulatory menses being allowed to occur every 4th month before therapy is resumed.

5. This treatment is effective as a temporary method of relief only. It does not constitute a cure for essential dysmenorrhea.

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| 2. S. H. and  | and November 1944 |
| 65-72.        |                   |

# THE ANGIOCARDIOGRAPHIC DEMONSTRATION OF AN ARTERIOVENOUS FISTULA

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THE roentgen demonstration of peripheral arteriovenous fistulas has been accomplished by the introduction of radio-opaque substances through direct arterial punctures (1, 2, 3, 6, 7, 8). Both thorotrast and diodrast have been used. Direct puncture is limited to those vessels which are easily accessible. The femoral, brachial, and radial arteries have been most commonly utilized for this purpose. When the involved vessels are deeply situated, direct arterial puncture is not feasible, and surgical exposures of the artery proximal to the fistula must be performed in order to introduce the opaque substance safely and successfully. Gross (4, 5) has obtained successful intracranial angiograms of arteriovenous aneurysms of the circle of Willis by injecting diodrast 50 per cent directly into the common carotid artery exposed through a cervical incision. A similar technique might be utilized for such deep intrathoracic vessels as the innominate and subclavian arteries. However, this involves a formidable surgical procedure and may be especially difficult in the presence of the increased vascularity associated with the arteriovenous communication. A much simpler method is available through the application of the angiocardiographic technique. This consists of the rapid introduction of diodrast 70 per cent through a special needle (Robb and Steinberg) into an antecubital vein making serial roentgen exposures which may be recorded either fluorographically or roentgenographically (10, 11).

## CASE REPORT

No 461436 D B, a 13 year old girl, suffered a severe trauma to the head at the age of 4 when she was hit by a towing truck crane. At that time roentgenograms were made and failed to reveal a fracture. Following the accident the child's mother noted enlarged veins in the left arm. These increased in size. Mental development was definitely retarded. Four years previously school physicians had advised hospitalization for study and treatment of the vascular disorder. Studies were made but no treatment was instituted. Patient had no local or general symptoms aside from slight breathlessness upon exertion. She en-

tered Mount Sinai Hospital on May 4, 1940, for investigation.

Physical examination revealed a well nourished and moderately well developed girl of 13 with definite mental retardation (Binet, 9 years). The left side of neck and supraclavicular fossa showed definite expansile systolic pulsation, a marked thrill and bruit were present over this site. Compression of the subclavian vessels by means of pressure over the supraclavicular region abolished these and the resting pulse of 95 per minute dropped sharply to 52 per minute. Pressure over the axillary artery produced neither of these effects. Measurements of the upper extremities showed the left to be definitely larger than the right. Skin temperature was 2 degrees C higher on the left side. The superficial veins of the entire left extremity were very much dilated and pulsated in systole. The left radial pulse was weaker than the right. Blood pressure was 96/30 in right arm, 128/60 in left arm. The retromanubrial dullness was enlarged to the left. There were many dilated superficial vessels over the chest. An enlarged tortuous pulsating artery was felt over the left shoulder anteriorly. The heart was enlarged to the left—apex percussed to anterior axillary line in 5th intercostal space. A thrill was felt over midclavicular region but not over heart. At apex a systolic murmur was heard  $P_2 > A_2$ , rhythm was regular.

Laboratory data. Venous pressure was 12.2 centimeters (right arm). Following pressure on right upper quadrant—13.4 centimeters. Circulation time was 12 seconds (saccharine). Oscillometric readings were right arm, 3, left, 20+ right forearm, 2, left, 8, right leg, 2, left 2. Wasser mann test showed negative reaction. Total blood volume was 3438 cubic centimeters, red cell volume, 36 per cent, volume per kilogram, 112 cubic centimeters, hemoglobin, 110 per cent (Sahle).

Roentgenograms of the chest revealed a considerable degree of enlargement of the heart, particularly the right side. The superior mediastinum was widened. This later proved to be due to a markedly dilated superior vena cava, demonstrated angiocardiographically.

Roentgenogram of the left humerus showed the entire shaft of this bone to be replaced by an irregular vacuolization present both in the cortex and medulla. This was later shown pathologically to represent vascular channels which had completely replaced the normal bone marrow.

Electrocardiogram showed regular sinus rhythm, rate 95, left axis deviation, PR, 0.22 seconds. Compression of subclavian vessels slowed heart to 52 per minute.

Phonocardiogram showed first sound normal, followed by prominent high pitched systolic murmur, loudest at Erb's area. This was recorded also in left axilla. An auricular and third heart sound are present at apex.

A clinical diagnosis of arteriovenous fistula of the left subclavian artery was made. Because the bruit disappeared upon pressure over the subclavian vessels while similar pressure over the axillary vessels produced no such effect, it seemed most probable that the site of the fistula was between the subclavian vessels. The etiology was undetermined. It was suggested by some that it might be congenital. However, in view of the history of a severe

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Fig. 1. Injection of antecubital veins on involved side, left. a, Film taken during the injection. Delayed axillary-subclavian and innominate veins on the left side are visualized. Retrograde opacification of left internal jugular and subclavian veins. b, Film taken 3 seconds after beginning of injection. The veins have opacified. The aorta is opacified. c, Film taken 5 seconds after beginning of injection. The axillary and brachial arteries are now visualized, the opaque substance having entered the systemic circulation from the heart. The subclavian artery is not seen. d, Film taken 7 seconds after beginning of injection. The axillary artery and vein are both opacified. There is also visualization of intercostal vessels—the head of the hemothorax.

trauma to left side of head at age of 4, it was felt by others that it had most likely been acquired at that time.

Although the clinical picture was unmistakably that of an arteriovenous fistula, more accurate localization of its site was considered highly desirable before operative intervention. The sur-

gical approach for a fistula between the subclavian vessels would be transthoracic, while that for a fistula between the axillary vessels could be entirely extrathoracic. In order to determine the site of the fistula, therefore, angiocardiology was performed.



Fig 2 Injection of antecubital vein on the uninvolved side, right a, Film taken 6 seconds after beginning of injection The left axillary artery and branches to the head of the humerus are visualized, the opaque substance having reached the systemic circulation after traversing the heart and lungs b, Film taken 7 seconds after beginning of injection The dilated left axillary vein is shown caudad to the artery The tortuous channels extending into the head of the humerus are seen c, Film taken 8 seconds after beginning of injection The left axillary vein is still visualized while the left axillary artery is fading d Film taken 9 seconds after beginning of injection The artery is no longer opacified The tortuous channels to the head of the humerus are still visible

Two injections of 30 cubic centimeters of diodrast 70 per cent were given, the first into the left antecubital vein, the second into the right antecubital vein. Roentgenograms were taken rapidly with the x-ray tube centered over left supraclavicular region, shoulder, and upper arm.

Injection of the left antecubital vein, involved side (Fig 1), definitely established the identity and size of the left axillary, subclavian and innominate veins and the axillary artery. It was evident that the opaque material must have reached the axillary vein directly from the axil-



Fig. 3. Roentgenogram of the chest revealed considerable degree of enlargement of the heart, particularly the right side. The superior mediastinum was widened. This later proved to be due to a markedly dilated superior vena cava, demonstrated angiocardographically.



Fig. 4. Roentgenogram of the left humerus shows the entire shaft of this bone to be replaced by an irregular vacuolization present both in the cortex and medulla. This was later shown pathologically to represent vascular disease which had completely replaced the normal bone marrow.

lary artery at a point near their origin, since both of these vessels were simultaneously visualized. It was likely that the actual fistula was present at a point proximal to the origin of the axillary vessels. The third portion of the subclavian artery was, therefore, designated as the probable site of the fistula.

Injection of the antecubital vein was also made on the uninvolved side (Fig. 5). Revisualization of the axillary veins without doubt confirmed the existence of a fistulous communication at a point above the origin of the axillary vessels.

Subsequent operative findings confirmed the angiocardigraphic localization of the fistula. A preliminary double ligation of the left axillary artery and vein was done but this resulted in no essential change in the clinical picture. The bruit persisted above the point of ligation and the heart size remained unchanged. An exploration of the proximal portion of the axillary artery at its origin revealed an arteriovenous fistula which was only partially excised. Complete obliteration of the fistula, however, was impossible at this time since its major portion involved the subclavian vessels. A later exploration of the third portion of the left subclavian artery was unsuccessful due to the enormous collateral circulation present in this

region. Finally, because of increasing cardiac failure, ligation of the first portion of the left subclavian artery was performed through a trans-thoracic, transpleural approach (1). This resulted in complete disappearance of all bruits and murmurs. The cardiac status eventually returned to normal. After operation a gangrenous involvement of the left wrist and hand due to impaired circulation necessitated a partial amputation of that extremity.

#### SUMMARY

1. Angiocardigraphy is a simple effective procedure for the precise localization of arteriovenous fistulas involving large vessels near heart.
2. It is especially valuable in cases involving those vessels which otherwise would require a difficult surgical exposure to perform arteriography.

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# FRACTURES OF THE HUMERAL CONDYLES IN CHILDREN

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**D**ESPITE the fact that a serviceable elbow seems to be recovered in most fractures of the humeral condyles in children, the surgeon cannot feel entirely satisfied with the treatment of these injuries. Under conservative treatment, which fails to ensure an accurate reduction, a successful outcome depends to a great extent upon the reparative power in the child. Admittedly this is not good fracture treatment. Under operative treatment, which makes possible an exact anatomical replacement of the fragment, more satisfactory results are obtained, and hence open intervention is the accepted method of treatment. Yet in the roentgenograms of the apparently accurately reduced fractures with excellent function, structural irregularities are seen which bring into question the efficacy of the treatment.

With a view to studying the end-results of the condylar fractures that have been treated or seen in our clinic, a series of 54 cases was compiled, on 32 of which it was possible to obtain a final report. The posttreatment period extended in several instances over more than 22 years. Of particular interest were the roentgenographic findings at the time of the final examination.

## ANALYSIS OF CASES

In the series of 32 cases there are 13 fractures of the lateral condyle, 16 fractures of the medial epicondyle, 2 of the less common fractures of the internal condyle, and 1 of the rare fractures of the lateral epicondyle. The group includes fresh fractures that were treated at the time of the injury and fractures of long standing that came to our attention because of impaired use, pain, or deformity.

*Fractures of the lateral condyle, 13 cases.* The ages of the patients ranged from 2 to 17 years. Six fractures had been treated conservatively, 5 of them by physicians outside of our clinic and 1 by the writer. Five of the patients, when an examination was made from 2 to 22 years after the injury, had good serviceable use of the elbow, in 3 cases the motion was practically normal, and in 2 cases there was only a slight limitation of motion and a slight change in the carrying angle of the arm. In the sixth case, when the examination was made 35 years after the injury, flexion was limited

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to about 50 degrees, extension to about 130 degrees, and both supination and pronation were restricted.

Of interest in connection with the 5 cases that had been treated conservatively outside our clinic was the variance in the amount of function when the writer first examined the patient, and later when the elbow was checked for this report. The 5 cases were first seen after a lapse of from 7 weeks to 13 years from the time of the fracture. In only 1 of these cases was the motion normal, and in the 4 other cases the function was limited and the elbow distorted. Yet when these 4 elbows were again examined, from 3 to 22 years after the initial injury, 3 had normal motion. Other observers have noted that although motion is restricted for a time after the fracture, the patient may eventually recover almost complete function of the joint (Fig 1).

Operative reduction had been carried out in 6 cases, 4 of which were fresh fractures and 2 of a month's duration. In 4 cases, upon examination of the elbow from 2 to 15 years after the fracture, the motion was perfect. In 1 case, when the end-result was checked 26 years after the fracture, the motion in flexion was limited 15 degrees and there was a cubitus valgus deformity of 15 degrees. In the sixth case, upon examination of the elbow 25 years after the operation, extension was limited to 140 degrees and flexion to 40 degrees.

In 1 case of a fracture of the lateral condyle, the fragment had been excised 11 days after an unsuccessful attempt at manipulation. The result was unsatisfactory, the patient having limited extension and flexion of the joint.

To summarize the results in fractures of the lateral condyles. Under conservative care 5 of 6 patients recovered satisfactory motion of the elbow joint, under operative treatment 4 of 6 patients recovered perfect function and 2 had slightly limited motion. In 1 case that had been treated by manipulation there was a restriction of all motions, and in 1 case in which the fragment had been excised there was a fairly marked limitation of motion. It is evident that equally good results seemed to be obtained from conservative and operative treatment of the fracture.

Whereas there was little difference in the clinical results under closed or open treatment, there was a contrast in the end-result roentgenograms of the



Fig. 1. a, Malunion in fracture of the external condyle of the left humerus, year after conservative treatment. Patient had restricted motion and cubitus varus deform-

ity. b, ten years after the fracture showing the new appearance of the external condyle. Patient moves practically normal motion.

two groups. In general the roentgenograms of the fractures that had been treated conservatively showed malunion and an overgrowth of the condyle. On the other hand, the roentgenograms of fresh fractures that had been treated operatively showed a well developed and accurately replaced condyle.

*Fractures of the medial epicondyle 16 cases*  
The ages of the patients ranged from 6 to 7 years. Six fractures had been treated by conservative reduction, 4 of them by physicians outside of our clinic. When these 4 elbows were examined after

a lapse of 6, 9, 12 and 13 years, respectively, only 1 had normal motion. Extension was limited in 2 cases, and both extension and flexion were restricted in the fourth case. One of the patients had an ulnar neuritis, which was the only case of this complication in the series. Of the 2 cases handled conservatively at our clinic, 1 had been so treated 25 years previously and 1 had been manipulated in recent years because the continuation of the fragment prohibited operative reduction. In both of these elbows a full range of motion was recovered.



Fig. 2. a, Displacement of the external epicondyle as the result of injury in childhood. b, One month later following treatment of the elbow in a plaster cast, showing problems of bone and absorption. c, Nineteen years later the external condyle head is well shaped, even though the epicondyle is missing.



Fig 3 a, Fracture of the external condyle of the left humerus b, Well developed external condyle 2 years after operative reduction

Seven fractures had been reduced operatively, 5 of them immediately after the injury, 1 within a period of 2 weeks, and 1 after the lapse of a year. All the elbows that had been reduced promptly were found to have good function when examined from 1½ to 10 years after the fracture. Both elbows reduced late were limited in motion, and 1 patient had an increased carrying angle.

Excision of the epicondyle had been carried out in 3 cases, 1 of which was a fresh fracture with a

small fragment, and 2 of which were of long standing. Excellent results were obtained in all 3 cases.

To summarize the results in fractures of the medial epicondyle. Operative treatment in fresh fractures gave excellent results, the motion being complete and the carrying angle normal. By conservative treatment a complete range of motion was recovered in only 3 of 6 cases.

In the roentgenographic study of the end-results the feature that stood out prominently was the



Fig 4 a Displacement in a fracture of the external condyle 7 weeks after conservative treatment in acute flexion

b The same fracture 17 years after the injury, showing the malposition, non union, and enlargement of the condyle



Fig. 5. End result in fracture of the external condyle years after conservative treatment in acute flexion, showing non-union and squatting out of the condyle.

overgrowth of the fragment and the tendency of the epiphysis to be displaced forward and downward. These changes were evident in all cases whether they had been treated by manipulation or by operation. Irregularities in the contour of the external condyle were associated with several of these fractures.

*Fractures of the medial condyle.*—cases. Both cases had been treated by manipulation outside of our clinic. One patient when examined 6 years after the fracture had only a slight limitation of motion in the elbow. In the other case in which



Fig. 7. The accurate reduction possible by operative treatment.



Fig. 6. End result in fracture of the external condyle 4 years after conservative treatment in acute flexion, showing malunion and squatting out of the condyle. Note Nature's attempt to provide a serviceable joint by condyle new articular surface.

the fragment had been excised 1 month after an unsuccessful manipulation, limited flexion, extension, and pronation resulted. The patient, however, had no complaint and was able to climb ropes in his work without any trouble.

*Fracture of the lateral epicondyle.*—1 case. This patient was not seen until she was 27 years old, but she had had an injury of the elbow in childhood which apparently had not been treated. At the time of the examination the elbow was tender, painful, and limited in extension and flexion. The epicondyle had been pulled off and the condylar area was infected (Figs. 2a and 2b). A plaster cast was applied and later a bone curetting was necessary. When the elbow was reexamined 19 years later the patient had complete motion in the joint and there was solid healing (Fig. 3c).

#### DISCUSSION

As is generally true when condylar fractures are treated conservatively, satisfactory functional results were obtained by closed methods in many of the cases in this series. There is, however, some question as to whether the results of conservative handling are generally as satisfactory or as numerous as they are claimed to be. Condylar fractures occur in children, and they are followed through to an end-result in only relatively small series of cases such as is presented in this paper. How many fractures terminate in a distorted elbow with limited motion is not known.

Slight limitations of motion in the elbow are likely to be disregarded by both the patient and the physician, since the joint bears no weight and 90 per cent of its useful function lies within the range of 60 degrees of flexion and 130 degrees of extension. Particularly is this true when the rotary motion is preserved, as it is in condylar fractures. In the presence of a limitation in extension of from 0 to 15 degrees, disturbances of the carrying angle are not evident.



Fig 8 a, The enlarged and displaced medial epicondyles in 3 cases following conservative treatment in acute flexion, 10, 6, and 13 years previously. Note the lack of ossification in all cases and the proliferation of bone in the external

condylar area in 1 case. b, The same enlargement and displacement of the medial epicondyle 3 years after operative reduction with suture of the fragment. Note the proliferation of bone in the external condylar area.

It is also possible that deformities give rise to no symptoms because the elbow in childhood is not called upon for heavy work. Only in later life when the elbow might be subject to heavy usage would the joint cause any difficulty. Unfortunately, in the series of cases reported little light was thrown on how the elbow would withstand strain, as none of the patients did heavy work,

although most of them had reached adulthood at the time of the final examination.

The roentgenographic study of the end-results was interesting. In fractures of the external condyle that had been treated operatively, the roentgenograms showed a well developed condyle in good position (Fig 3). Under conservative handling of the fracture an enlarged condyle with non-union or malunion resulted (Figs 4, 5, and 6). Figure 7 shows the accurate reduction possible by operative treatment and may be contrasted with Figure 5 showing the distorted elbow in a fracture that was treated conservatively. Figures 5 and 6

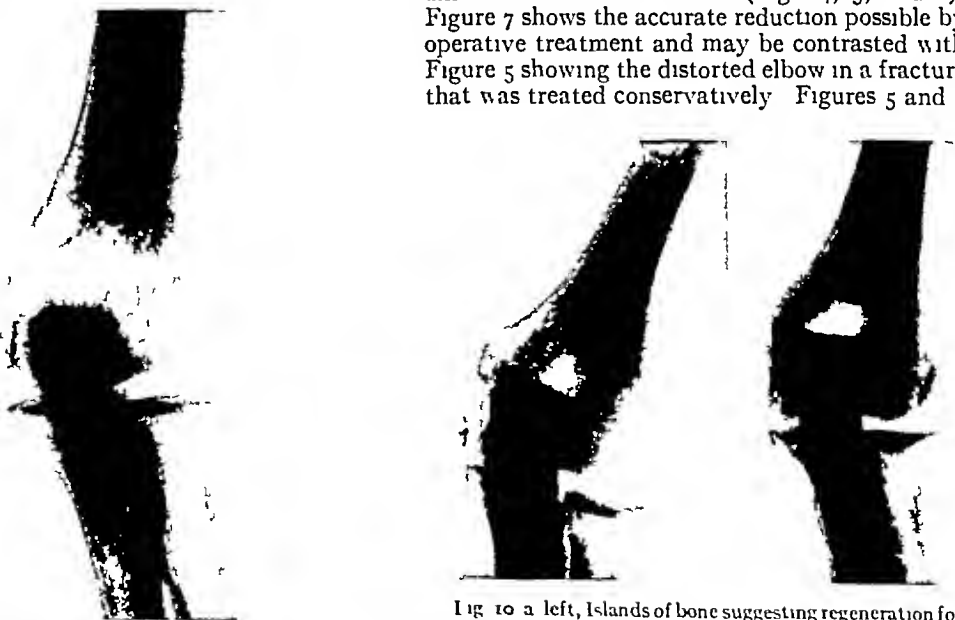


Fig 9 Ossification of the medial epicondyle in a patient 2 years of age.

Fig 10 a, left, Islands of bone suggesting regeneration following excision of the medial epicondyle 13 years previously. b, The same regeneration in a case treated by excision of the fragment 16 years previously.



show clearly the nonunion, malunion, and squatting out of the condyle when the fracture is treated with the elbow in the position of acute flexion. The latter roentgenogram also illustrates well the effort on Nature's part to provide a serviceable joint in the presence of deformity.

Roentgenographic studies of the end-results in fractures of the medial epicondyle usually showed an enlarged fragment that had pulled away from its bed. These changes were observed in cases that had been treated either operatively or conservatively (Fig. 8). It is difficult to explain such findings in cases that have been reduced accurately. Either still better replacement of the fragment or more efficient immobilization may be necessary. The favorable time for operation may be questioned, it being possible that the operator should wait for the blood clot to be absorbed instead of reducing the fracture immediately.

The fact that such irregularities appear in the end-result roentgenograms of accurately reduced fractures of the medial epicondyle should be kept in mind in handling long-standing and neglected fractures that present a similar picture. Conservative treatment would seem to be preferable to operative excision of the fragment in such cases. If the fracture is recognized only after a superimposed injury and the case happens to be one of litigation, a great deal of emphasis may be placed on the roentgenographic findings until it is pointed out that the same irregularities appear in the accurately reduced fractures.

The proliferative islands of bone that showed around the outer margins of the joint in fractures involving the medial epicondyle are probably due to the original injury and to the attempt to force the motion of the joint (Figs. 8a and 8b).

The failure of union between the medial epicondyle and the humeral shaft which normally takes place about the 8th year of life, was noted in most cases (Fig. 8). There were 7 patients over nineteen years old and yet in only one case had the epicondyle joined the shaft (Fig. 9).

Of particular interest in the roentgenograms of cases of operative excision of the medial epicondyle were islands of bone that suggested regeneration (Fig. 10). The possibility of such regeneration has been mentioned by Vossell and Taylor.

Both clinical and roentgenographic findings point to the fact that operative intervention is the effective method of treatment in fractures of the external condyle. Open reduction is also the preferable method in fractures of the medial epicondyle, ensuring an accurate reduction, although the findings in the end-result roentgenogram cannot be explained. In the latter fracture, if conservative treatment must be considered because of contraindications to operative reduction, there would seem to be a better chance of obtaining a favorable result than under similar circumstances in fractures of the external condyle.

Operative reduction is a simple procedure. It is carried out immediately after the injury. The muscle attachments are pulled upward, and the fragments approximated. All soft tissue should be preserved.

The method of maintaining the position of the reduced fracture depends upon the nature of the pathology. The larger the fragment, the greater volume of muscle attachments, the better the fixation needed. The writer uses either chromic catgut sutures or a vitallium nail of small caliber in fresh cases, and a nail in cases of long standing. When necessary the nail may safely be driven through the epiphyseal plate.

The position in which the elbow is maintained during the healing process is governed by the pathology, but flexion of the joint to a right angle is preferable to full flexion. In order to relax the muscles, it is advisable, unless some form of internal fixation is used, to flex the wrist in fractures involving the medial epicondyle and to hyperextend the wrist when the external condyle is involved.

Following the reduction, the fracture should be allowed to heal solidly before motion is permitted. The practice of forcing the joint to obtain motion by such measures as carrying heavy weights cannot be condemned too strongly. In any type of fracture such procedure causes further damage to the joint. Provided there is no bony block to motion and no scar-tissue formation motion will return upon the resumption of use.

# SURGICAL TREATMENT OF PERIPHERAL ANEURYSM

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THE World War was a great stimulus to blood vessel surgery and this country's involvement in a second war of survival in our time makes the subject of surgery of aneurysm even more timely.

The definition of aneurysm as a blood filled sac communicating with an artery at once needs elucidation, because the multiple forms and sites at which it may occur in the human body, as well as the different causes, make this more a syndrome than a specific disease. It is apparent that the symptoms and treatment will vary greatly, depending on whether the lesion is near the aorta or in a terminal vessel. Efforts to classify and outline aneurysm are difficult, and under the aneurysm title in the *Quarterly Accumulative Index Medicus* may be found an average of 24 subheads in the volumes of the last 5 years. In order to simplify this discussion, peripheral aneurysm will be divided into the two types interesting to us surgically, the arteriovenous aneurysm, in which there is a communication between the artery and the vein either directly or through a dilated vascular mass, and the aneurysm involving only the artery itself. Aneurysms of the heart, aorta, and skull are not included in this discussion. While our subject is treatment, classification of various types of aneurysm will be discussed briefly. Peripheral aneurysms may be arteriovenous or arterial and either one may be congenital or acquired as the result of trauma or degenerative disease.

Such adjectives as cirroid, dissecting, idiopathic, traction, and diffused but add to the confusion, anatomical and pathological differentiations, due to the site or the true or false walls, need to be considered only in the light of their effect on treatment. Gunshot and stab wounds, as well as airplane and automobile accidents, are the most frequent causes of acquired aneurysms.

## ARTERIOVENOUS ANEURYSM

### ACQUIRED ARTERIOVENOUS ANEURYSM

The acquired arteriovenous fistula is most often single, frequently a direct opening, and is seen fairly frequently in surgical practice. William Hunter was the first to describe it, and while in

1920 Callender had found only 444 cases in the literature up to that time, this number has more than tripled since. Symptoms vary with the site and extent of the fistulous opening. Experimental data have convincingly shown that certain physiological changes occur when a fistula develops. The immediate changes are (1) a fall in general arterial pressure with a gradual recovery, the systolic pressure being equal or higher and the diastolic lower—thus a greater pulse pressure, (2) an increase in pulse rate, (3) an increase in venous pressure, (4) an increase in the cardiac output, depending on the size and location of the fistula, (5) a very temporary decrease in the size of the heart and the artery proximal to the fistula, due to the blood flow in the large venous system, followed by a gradual dilatation of the heart, artery, and vein proximal to the fistula, with hypertrophy of the heart, (6) gradual increase in the total volume of the blood, (7) development of collateral circulation around the fistulous site.

These points must be kept in mind in the consideration of the therapy. If the arteriovenous fistula is large, it must be repaired or definite, permanent damage to the heart will result. The symptoms in the acquired type are usually so apparent that the diagnosis is evident. The scar at the site of injury, followed by an enlargement of the part, increased temperature, the dilatation of the veins of that extremity, together with the bruit at the site of communication is confirmatory. An arteriogram will determine the extent of pathology present and occasionally other anastomoses are revealed by this method. Pressure over the site of the fistula will cause a decreased pulse rate—the Paré sign. An analysis of the blood in the tributary veins shows a higher oxygen content than in other veins. Pain is an inconstant sign but in the large ones usually develops with pressure on nerves or other sensitive parts. All of the symptoms accompanying a reversed flow in veins may occur, such as pigmentation, ulceration, dermatitis, hemorrhage, and gangrene.

**Pathology** The endothelium soon lines the connection and coagulated blood in the sac is not unusual. The arterial pressure drives the venous blood back during systole, while in diastole venous blood may actually enter the artery. This mixture of venous and arterial blood causes venous stasis. The arterial blood returns directly through

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Fig. 1. Arteriogram of congenital arteriovenous fistula involving the ulnar artery. There are aneurysmal connections present. The entire artery was eventually removed.

the venous channels, frequently without being carried through the capillaries, and starvation of the periphery may occur with trophic changes.

**Surgical treatment.** It is wise to postpone operation until 4 to 6 months after the development of the fistula to permit the sudden physiological changes accompanying the fistula to have reached a level and, more important, to permit collateral circulation to become adequate. At the time of the repair the physiological changes previously mentioned must be considered, as the closure of the fistula causes an exact reverse of all the processes mentioned. If the fistula has been present for a long time it may be necessary first to decrease the total blood volume by phlebotomy to prevent overstrain of the cardiovascular system. Operation is best performed without the use of a tourniquet and no one operative procedure is applicable for each type of fistula. Theoretically the ideal treatment would be one in which the fistulous communication could be closed and the continuity of the involved vessels re-established



Fig. 2. a, above, Large aneurysmal artery connecting to femoral bulb, fed by several small arteries. b, Manual reduction of these aneurysms.

Thus is rarely possible. The site of anastomosis should be exposed and explored. Temporary tapes above and below the fistula should be applied. If collateral circulation is adequate, the closing of the upper tape will not result in circulatory failure distally and this effect can be observed at this time. The type of operation which is to be selected may be one of the following presented.

Repair of the fist is in the arterial wall through the opened and sacrificed vein. Suture materials should be of the finest arterial silk or nontraumatizing minute, round needles, such as are used in eye surgery. These sutures should not enter the intima. A section of nearby fascia or muscle makes a better re-enforcement than the fistulous sac. The ligation of the vein in these instances appears to be of therapeutic value compensating for the reduced arterial supply by decreasing the rapidity of the blood return.

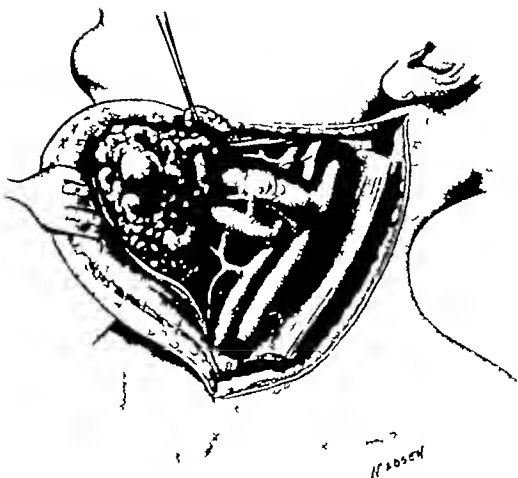


Fig 3 Large arteriovenous fistula of the neck First stage excision of left superior thyroid, lingual, and external maxillary arteries and facial vein

2 Ligation, proximally and distally, of the artery and the vein with excision of the intervening fistula and vessels is frequently the treatment of choice when collaterals are adequate. In this type of treatment the intervening vessels must be removed or the fistula may recur. This operation is used most often in the upper extremity, head, or neck.

3 In some cases it is impossible to remove the fistula because of possible damage to secondary circulation. Quadrilateral ligation is then performed. The fistulous tract is opened and the clots evacuated, all openings into the fistulous tract are closed by fine arterial sutures and the sac is obliterated by imbrication and plication, as in the Matas endoaneurysmorrhaphy operation, or implant of muscle. The use of this operative principle has saved many limbs which in previous years it has been necessary to sacrifice.

#### CONGENITAL ARTERIOVENOUS FISTULA

The etiology of congenital arteriovenous communications is still under investigation. Arteries and veins normally anastomose in man in only the hands, feet, and the sexual organs, as shown by Hoyer, Krogh, and others. In studying the embryological rests frequently demonstrated in the newborn, it is not difficult to conceive of the same failure of closure in the arteriovenous system. These communications are usually multiple. They may occur in any part of the body but are

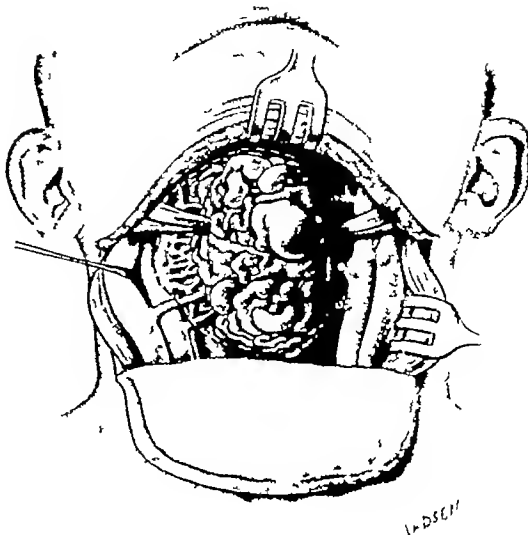


Fig 4 Same patient as Figure 3 Second stage excision of entire mass and right external carotid artery and its branches *en masse*, with cure



Fig 5, left Congenital arteriovenous fistula. Entire upper extremity, shoulder, and chest, with invasion of brachial plexus. Some blood vessel tumors have the characteristics of malignant neoplasms.

Fig 6 Roentgenogram of arterial aneurysm of the brachial artery following gunshot. Aneurysm began to grow when slightly traumatized 20 years after injury. Doubled size in 1 month. Treatment obliteration with cure. Note calcification.



Fig. 7. End-to-end arterial suture with fine arterial suture. Adaptation of Farr retractor approximates arterial ends without trauma. Suture completed without entering lumen.



Fig. 8. Completion of suturing and re-approximation of anastomosis with contigous muscle flap.

particularly frequent in the upper extremities (Fig. 1). Many times, especially in the lower limbs, they are diagnosed as varicose veins and the usual history is that the abnormality was noticed at 3 to 5 years of age, but that the physician consulted advised that nothing be done as the patient might grow out of it. Another form of arteriovenous connection is the so called aneurysmal varix, in which enlarged varicose veins connect with an artery (Fig. 2). This is not a rare lesion. It is frequently diagnosed and treated as varicose vein with resulting technical complications. The symptoms in the congenital type vary with the number, size, duration and position of the communications. Minor ones may occur on the face particularly around the eyes and mouth when the term pulsating hemangioma has been applied. The large ones are particularly frequent in the upper extremities. We have seen a congenital fistula in the neck in a patient of Dr. Irving S. Wright, in which a large mass of vessels in the

suprahyoid muscle area was fed by the left lingual, external maxillary and inferior thyroid arteries and so many abnormal connections from the right external carotid that the extirpation of all of those main branches of the left external carotid and the entire right external carotid artery was necessary to close the fistula (Figs. 3 and 4). The signs of thrill and bruit at the fistula site as well as arterial blood in the veins present a picture similar to that in the acquired type of fistula except for the fact that the congenital fistula is usually larger than the acquired one.

*Treatment.* In the small fistulas, particularly those on the face, extirpation frequently is sufficient to cure them. In selected instances a sclerosing solution judiciously introduced has eliminated the main pulsating varix, and in a small number radium has been satisfactory. In undertaking the treatment of the large congenital connections, one finds that multiple and frequently heroic operative procedures may be necessary. The most important thing to remember is that the connection



Figs. 9, left, and 10. Aneurysm of radial artery following laceration with glass. End-to-end arterial suture with establishment of circulation.

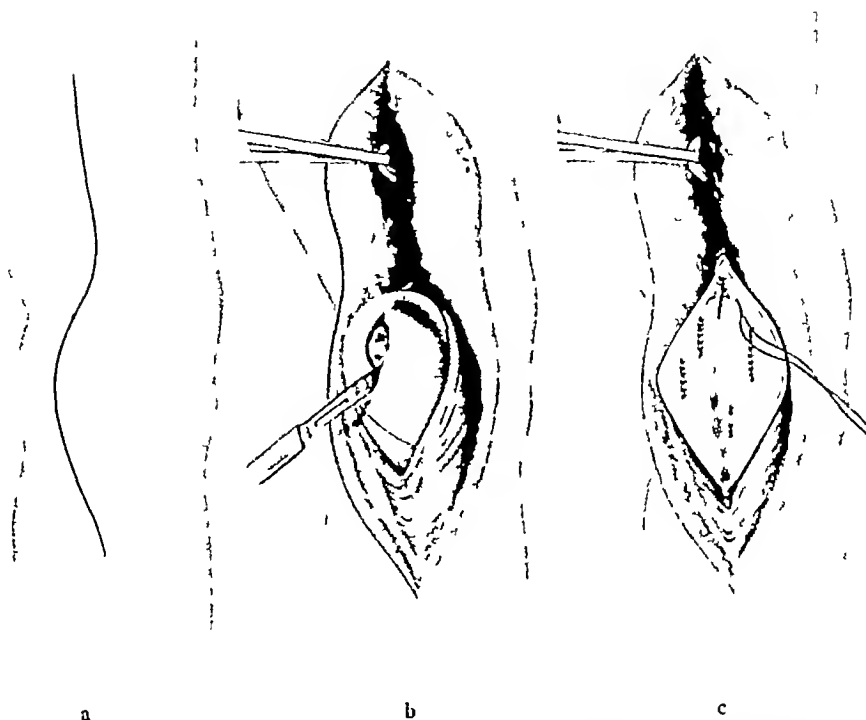


Fig. 11 a, Line of incision for a popliteal aneurysm b, Control of circulation proximal to the aneurysm by tape and incision of aneurysm and evacuation of clots and debris. Note sural nerve which must be protected c, Suturing of all collateral openings, ligation proximally and distally, and closure of artery aperture from within sac

are usually multiple and the disheartening thing is that one may close 8 or 10 connections and have a recurrence due to the opening of another connection not patent at the first operation. It is our practice to operate on these patients without a tourniquet. The fistulous connection can then be localized with a sterile stethoscope. The extent of operative treatment is determined only by the pathological condition present, but one should not discontinue the operation until each fistulous opening and bruit have been eliminated. The site of the fistula should be exposed widely enough to permit control of normal vessels proximally and distally. The operation of choice in the large lesions is quadrilateral ligation and excision of the arteries and veins involved. At times one must remove vessels which appear necessary to the life of the part, but collateral circulation is present so frequently that most of these limbs will not be lost.

Some of the congenital communications act as newgrowths, invading all layers of tissue including bone. One of our most alarming problems arose

from hemorrhage of the bone canal after an amputation for spontaneous gangrene in one of these growths. Matas has recently reported a case of this type in which there appeared to be metastasis. One of our patients showed similar characteristics (Fig. 5). In operating on a large and multiple arteriovenous fistula it must be remembered that while local relief is to be hoped for, the operation primarily is being done to prevent the cardiovascular failure which will eventually result. Sometimes amputation is necessary and indicated as a last resort to achieve this end.

#### ARTERIAL ANEURYSM

Any condition which weakens the wall of a vessel or increases the intra-arterial pressure is a cause for arterial aneurysm. A blood containing cavity which communicates with the artery is the result. This sac normally has a neck where it communicates with the main vessel and the contents of the cavity are either liquid blood or coagulated blood which is in various stages of resolution.

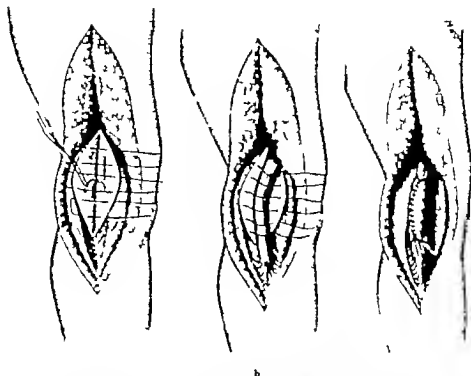


Fig. a, Obliteration of aneurysm by removal of suture line. b, Muscle flap patch. In this instance, section of paratracheal artery. c, Obliteration of aneurysm without its removal, thus protecting collateral vessels.

**Symptoms.** Tumor is considered synonymous with aneurysm, and it will always be found unless it is concealed beneath contiguous structures such as heavy muscles. It has an expansile pulsation until the laminations become so great as to obliterate it. The larger and later ones are not necessarily expansile. Pain is more or less a constant symptom but is most often due to pressure on other sensitive structures. Pressure signs depend entirely on the site and in the extremities are not a great factor. The pulse is always weaker or absent distal to the aneurysm and oscillographic recording of this fact may be an early suggestive sign. The bruit described by Paré in 158 is present in the early aneurysm before clotting is a fact and it is a rough systolic type of bruit.

**Pathology.** The pathological picture depends on the type. The diseased arterial wall may balloon out as a sacular or fusiform dilatation. Fibroconnective tissue strives to strengthen this wall, but the pressure eventually causes further dilatation. The walls of the vessel may be pushed ahead of it, forming the so-called true aneurysm, or the walls may be destroyed and the aneurysm consist of surrounding tissues with only an endothelial lining. Clots

which occur are white at the periphery and, as the lumen is approached, become red and more fluid. Many degenerative changes occur in the clots, and the long-standing ones calcified particles. Calcification of the entire clot is seen (Fig. 6).

**Treatment.** In a small percentage of the acquired type of aneurysm an end-to-end arterial suture is possible. The artery is exposed, the aneurysm resected, and the arterial ends sutured with interrupted and continuous fine silk (Fig. 7). The suture line is then re-enforced with a section of contiguous muscular fascia (Fig. 8). This treatment is applicable only when there is no disease of the artery and when the size of the aneurysm permits approximation of the ends. Inasmuch as many of these injuries occur at or near joints, by proper flexion of the part and release of the vessel from the surrounding tissues as much as a 4 centimeter defect may be closed. Such a procedure was satisfactorily performed four times last summer on large traumatic aneurysms (Figs. 9 and 10). It is particularly important to remember this point in war surgery when many limbs are unnecessarily sacrificed.

*Modifications of the reconstructive aneurysmorhaphy* In this operation modifications of the original Matas procedure are performed. Opening of the aneurysm and plastic repair of the wall over a tube or other foreign material have been successfully accomplished in selected cases although an arterial wall once seriously damaged may weaken again. The use of an absorbable material, such as a glucose preparation, to suture over has been advocated but has many technical difficulties. Vein transplants for arterial loss have been satisfactorily introduced. These vein transplants in the absence of thrombosis work well, the vein wall constricting to the size of the arterial flow and in time hypertrophying. Heparin is indicated, especially in these patients.

*Modification of Matas' obliterative aneurysmorhaphy* This operation follows the conceptions of Philagrius of over a thousand years ago and is the operation of choice in many cases. With the circulation controlled, the sac is opened, its contents removed, and the opening of the small collaterals into the sac closed by sutures. The sac is then obliterated by layer after layer of sutures without excising the sac. Most surgeons misconstrue this conception of the technique and remove the sac with irreparable destruction of the collaterals, and the frequent result is gangrene (Fig 11). When the sac is large, a muscle implant is most effective in obliteration.

It is interesting to consider the possibilities of other foreign matter causing periarteritis and endoarteritis in the future treatment of aneurysms and experiments at the present time are under way with such materials as talcum powder and

cellophane. These and other similar substances have shown remarkable tendency to cause inflammation and fibrosis, and it may be possible to take advantage of this fact therapeutically. One such patient has already been operated upon—with cellophane wrapping of aneurysm of innominate artery.

One must remember that in any type of treatment of aneurysm in which the main vessel is or may be occluded stimulation to collateral circulation should be continued. This stimulation should be in the form of controlled, external heat, avoidance of all trauma, the antispasmodic drugs, and whiskey. The lumbar sympathetic nerve block by use of 2 per cent novocain introduced into the sympathetic ganglia has its place in relaxing spasm and opening collateral circulation. Heparinization after operations on the arteries has revolutionized this form of surgery and has made possible procedures which previously were technically impossible. Heparin is given in a continuous drip with careful and constant checking of the clotting time to keep the figure above 15 minutes. This requires diligence. Murray has stressed this point and its importance has been proved in our own clinic to our entire satisfaction. The patient should not be left alone after such an operation until the success or failure of the procedure has been determined.

No strain should be put on the part until proof of adequate circulation is present, and in those cases in which small collaterals are carrying on the circulation the patient thereafter must be restricted physically to the limits of his arterial supply.



# THE OMENTUM AS A SOURCE OF NUTRITION TO EXPERIMENTALLY PRODUCED MYOCARDIAL ISCHEMIA

KARL FRIEDBACHER, M.D. F.A.C.S., West Allis, Wisconsin

**E**NCOURAGED by the results of our first experiments a second series of operations, omentum to heart graft, followed by coronary artery division and ligation, was undertaken. The results show that the new vessels formed are of sufficient caliber actually to carry enough blood to nourish that part of the myocardium to which they have proliferated. As evidence of this, injected particles of red cinnabar passed readily through the arterial anastomoses that developed between the omental and coronary arteries. Cinnabar particles are larger than red blood cells and they are also unlike corpuscles in so far as they cannot be squeezed into amoeboid shapes.

Electrocardiographic studies made throughout the experiments reveal serious myocardial changes following coronary artery division and ligation. The animals survive this shock with surprising ease and soon appear well except for the discomfort of the incision. Electrocardiograms show that infarcts develop but healing progresses rapidly. It was our hope that, by first developing a sufficient proliferative graft and then reducing the myocardial circulation, the process of infarction could be prevented.

To date we have been unsuccessful in this endeavor. All animals which had a graft and one coronary artery divided near its base recovered. On several occasions after a reasonable length of time had elapsed we divided the second coronary artery. None of these animals survived the operation by more than 10 to 30 minutes.

August 9, 1941 under intratracheal ether anesthesia with controlled artificial respiration, the left anterior chest cavity was opened and the omentum brought up through an incision in the left cupola of the diaphragm. The pericardial sac was then incised and the parietal pericardium as well as the epicardium thoroughly roughened with a burr. The omentum was then stitched with No. 00 plain catgut to the anterior and lateral walls of the heart and to the inside of the posterior portion of the pericardial sac. Special effort was made to bring the omentum well over

the base and apex of the heart. The pericardial sac was left open and after the diaphragm incision was sutured so as not to strangle the omentum, the chest wall was closed like the lungs were being artificially inflated.

On September 14, 1940 the right coronary artery was divided about one centimeter from its origin. The cut ends were ligated with No. 1 plain catgut. The omental graft had taken but there were very few myocardial surfaces seen. The dog recovered rapidly and, on October 26, 1940, a third operation was performed. On this occasion all accessible myocardium, which did not have omentum adherent to it, was roughened and omentum stitched in place. Again recovery was successful.

On February 3, 1941 the animal was sacrificed and a postmortem examination performed. The omentum was found to be adherent to most of the myocardium, pericardium, and lungs. The coronary vessels could not be seen until they were exposed at some places by blunt dissection of the omentum and at places by dissection of the pericardium. The heart, lungs, and diaphragm were removed as one unit and the specimen was injected with red cinnabar in water, the injection being carried out through the ascending thoracic aorta. Pulatile pressure producing an artificial systolic pressure of not more than 135 millimeters and a diastolic pressure not more than 95 millimeters no less than 1 millimeter was used. The cinnabar passed readily into the left coronary artery and then into the remnant (reticulum) of the right coronary artery. This latter vessel extended about one centimeter from the aorta, gave off eight very small branches and one fairly large anterior branch. The second centimeter of the right coronary artery was entirely absent, but from then on the distal portion filled completely. Before the coronary arteries had become well filled, the injected medium was seen flowing freely in numerous omental vessels and to a lesser extent in the diaphragm and lungs. The aortic valve held so perfectly that the left ventricle did not become filled with cinnabar during the injection.

This specimen was then dehydrated with alcohol and cleared by using the Spalteholz method of displacing the alcohol with benzine and then displacing the benzine with methyl salicylate. After



Fig 1



Fig 2

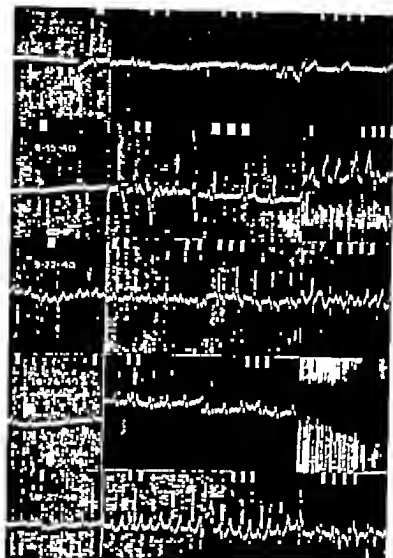
Fig 1 *D*, right auricle, *E*, destroyed portion of right coronary artery, *F*, peripheral stump of an omental artery, *G*, branch of proximal stump of right coronary artery, *H*, adherent lung, *J*, infarct, *K*, omentum artery, *L*, diaphragm

Fig 2 *A*, descending ramus of left coronary artery enmeshed in vast network of anastomotic omental vessels, *B*, omentum

Fig 3 *C*, omental graft partially dissected away to show the origin and branches of the left coronary artery



Fig 3



July 27, 1940. Marked sinus arrhythmia, rate, 60-70. QRS complexes, clear and of good amplitude in all leads. S-T and S-T practically isoelectric, but definitely convex upward. S-T slightly elevated and slopes upward. T flat. T upright, P R, 0.09. QRS 0.4.

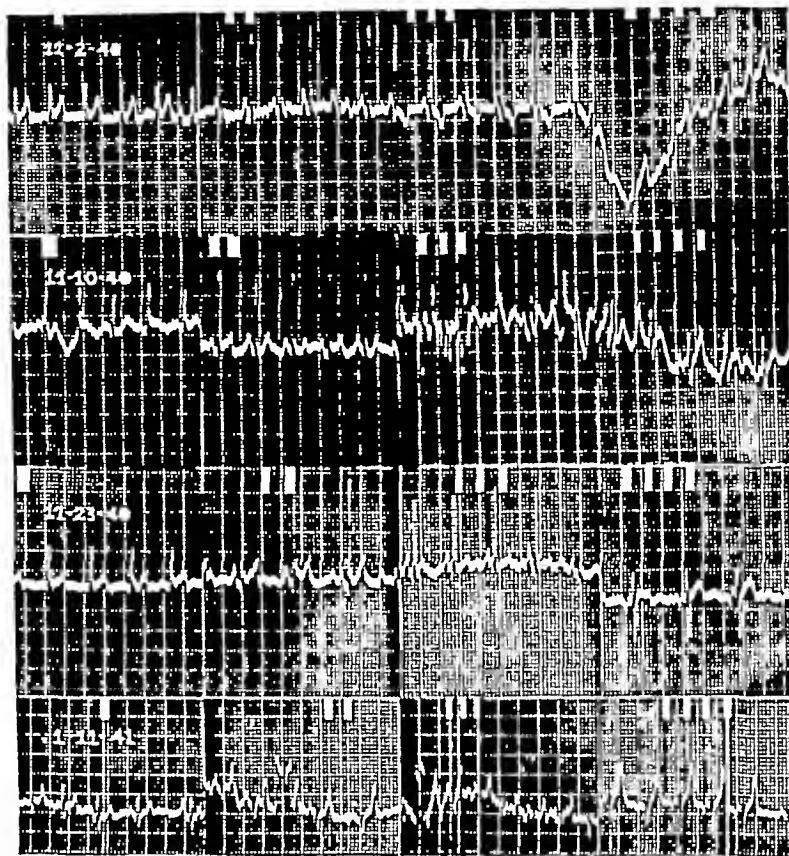
September 5, 1940. One day postoperative. Rhythm is composed chiefly of succession of extracardiac ectopic beats with occasional runs of two to four normal beats. R-R 90. Marked right axis deviation, QRS complexes, notched in all leads. T<sub>1</sub> inverted. T and T upright follow the more normal beats. R<sub>1</sub> beat T<sub>1</sub> inverted following normal beats. P R, 0.09. QRS 0.4. Consistent with recent myocardial infarction. Pattern suggests another pacemaker in the heart.

September 20, one week postoperative. Occasional extracardiac premature contractions. Sinus tachycardia, rate, 60. T<sub>1</sub> high as originally flat is now sharply peaked and

3 millimeters in amplitude. S-T and S-T slightly depressed. T<sub>1</sub> diphasic; T<sub>2</sub> high as previously upright, more sharply inverted. T<sub>3</sub> upright. P R, 0.09. QRS 0.4. Consistent with relatively recent myocardial infarction, probably involving posterior wall of left ventricle.

October 20, 1940. Sinus tachycardia, rate 70. T<sub>1</sub> is upright, but is now less than millimeter in amplitude. T<sub>2</sub> and T<sub>3</sub> low and diphasic. S-T and S-T have turned isoelectric, no lead IV. P R, 0.09. QRS 0.4. Consistent with healing infarction.

October 27, 1940, day postoperative, second stage. Sinus tachycardia. Rate 90. QRS increased in amplitude compared with electrocardiogram of previous day. R<sub>1</sub> relatively low. S-T elevated and convex upward. S-T and S-T depressed. S-T rather markedly elevated. T<sub>1</sub> has become inverted. T<sub>2</sub> has become deeply and sharply inverted. P R, 0.09. QRS 0.5. Fresh anterior wall infarction.



November 2, 1940 1 week postoperative third stage Sinus tachycardia Rate, 180,  $T_1$  and  $T_4$  have turned sharply upright and  $T_2$  has become sharply inverted as compared with electrocardiogram of 1 week ago,  $P R$ , 0.08,  $QRS$  0.05 These changes are exactly the opposite to what would have been expected after anterior wall infarction, and present pattern is more in keeping with posterior wall infarction

November 10, 1940 Third week postoperative Auricular flutter with 2:1 block, auricular rate, 336, ventricular rate 168  $S T_1$  has become depressed  $T$  waves are obscured by auricular flutter waves  $R_4$  and  $T_4$  still upright and of good amplitude Auricular flutter is most important

this process was completed, dissection was carried out in such a manner that many of the established anastomoses between the coronary arteries and the arteries of the omentum and lungs (bronchial) may be seen Numerous relatively small anastomotic connections were unavoidably destroyed in an effort to make visible the more important ones

finding Pattern of anterior wall infarction has disappeared suggesting complete healing  $P R$ , 0.08,  $QRS$ , 0.05

November 23, 1940, fifth week postoperative Sinus tachycardia Rate 150  $T$ -waves are upright in all leads and inconstantly notched in leads II and IV  $P R$ , 0.08,  $QRS$  0.05, no residuals of previous infarction

January 11, 1941 Sinus arrhythmia, rate, 120-190  $QRS_1$  increased in amplitude as compared with September 8, 1940  $S T_1$  has returned to iso electric,  $T_1$  increased in amplitude,  $T_2$  and  $T_3$  have turned upright and are of considerable amplitude  $P R$ , 0.09,  $QRS$ , 0.05 Suggests complete healing of infarct as there is no residual in electrocardiogram

#### CONCLUSIONS

1 Rich anastomoses between the omental arteries and those of the heart can be produced surgically

2 Anastomotic vessels are of sufficiently large dimensions to permit the blood to be carried freely through them

## FACTORS INFLUENCING THE INCIDENCE OF POSTOPERATIVE THROMBOPHLEBITIS IN GYNECOLOGIC SURGERY

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**T**HIS paper is based primarily on an analysis of the records of 99 patients suffering from postoperative thrombophlebitis which were selected during a review of 684 cases in which abdominal hysterectomy was performed consecutively for benign conditions from 935 through 939. A supplemental analysis will be made of 376 cases in which abdominal hysterectomy was performed consecutively in the hospital service of one of us (Counsellor) for a period of about 4 months. In this supplemental analysis (376 cases) the prevention of thrombophlebitis will be considered, whereas, the former and larger group (2,684 cases) will be arranged into groups of patients with similar complicating factors, and deductions will be made on the basis of the occurrence of thrombophlebitis in these various groups.

### INCIDENCE

We were primarily interested in determining the frequency of thrombophlebitis as it occurs after total or subtotal hysterectomy. Total abdominal hysterectomy was performed 920 times among the 2,684 patients; the 764 remaining patients underwent subtotal abdominal hysterectomy. It is evident that the frequency of postoperative thrombophlebitis is higher among those patients who underwent subtotal hysterectomy than among those who underwent total hysterectomy since in the 920 patients upon whom total hysterectomy was performed postoperative thrombophlebitis occurred in 66 patients, or 3.4 per cent, and in the 764 patients upon whom subtotal abdominal hysterectomy was done postoperative thrombophlebitis occurred in 33 patients, or 4.3 per cent—an incidence of 3.7 per cent for the entire 684 cases. To eliminate as many

other variables as possible and still further test this trend, we chose records of excellent risk patients from among records of the 2,684 patients. These patients were considered to constitute excellent risks because they presented no demonstrable disabilities such as hypertension, severe anemia, marked obesity or diabetes. By elimination of all cases in which undesirable factors were present we finally obtained records of 1,024 patients who underwent total abdominal hysterectomy and 463 patients who underwent subtotal abdominal hysterectomy. In the first group postoperative thrombophlebitis occurred in 35 patients or 3.1 per cent; in the second in 15 patients, or 3.0 per cent—an incidence of 3 per cent for the entire group of 1,487 cases. Thus it is shown that the same difference of occurrence of thrombophlebitis depicted in the total group of patients still exists. On the basis of these two figures a justifiable conclusion may be drawn: total abdominal hysterectomy is followed by a lower incidence of postoperative thrombophlebitis than is subtotal abdominal hysterectomy. The explanation of this difference probably lies in the relationship of the operation to the broad ligament. In subtotal hysterectomy the veins in the broad ligament are traumatized and left in place whereas in total hysterectomy most of the ends are excised or shortened and less endothelial surface consequently is left to act as a focus for the development of thromboses. Thrombosis in these venous stumps may slow the circulation in the proximal larger vessels (internal iliac), and these in turn cause additional venous stagnation, so that there is a tendency toward the production of more thromboses. Since lack of muscular action during the first 72 hours after operation is a prime factor in the production of thrombophlebitis after any operation and since traumatic changes in the iliac vessels subsequent to abdominal hysterectomy contribute to the process, the stage is set, so to speak, for formation of thrombophlebitis after an type of hysterectomy but even more so after the subtotal operation.

From the Division of Surgery, Mayo Clinic and Mayo Foundation.

Read before the meeting of the Western Surgical Association, 4, Paul, Minnesota, December 5 and 6, 1941.

Dr. Joseph Berkman of the Division of Radiology and Medical Statistics of the Mayo Clinic and his co-workers were of great assistance in the preparation of this paper.

TABLE I—INCIDENCE OF POSTOPERATIVE THROMBOPHLEBITIS AMONG PATIENTS WITH OPERATIVE HAZARDS AND AMONG "EXCELLENT RISK" PATIENTS

Hazard type	Postoperative thrombophlebitis		
	Patients	Patients	Percent
Varicose veins	86	20	23.3
Anemia			
Hemoglobin 50 per cent or less	50	4	8.0
Hemoglobin 70 per cent or less	157	11	7.0
Obesity	145	9	6.2
Endometriosis	238	14	5.9
Infection at time of operation	258	12	4.7
None ("excellent risks")	1497	37	2.5

## CAUSATION

Three possible conditions may influence the formation of thrombophlebitis (1) slowing of the circulation, (2) changes in the venous lining membrane, and (3) changes in the circulating blood. To apply these facts to the clinical field we further divided our patients into three groups.

In group 1 were those who had varicose veins at the time of surgical intervention. There were 86 patients in this group, but also included in the group were 145 obese patients. A patient 5 feet 2 inches (157 cm.) tall weighing between 140 and 150 pounds (63.5 and 68 kg.) was considered to have obesity of grade 1. Progressive disproportion between height and weight was graded as obesity of 1, 2, 3, and 3+. One hundred and thirty-one of the aforementioned 145 patients had obesity of grade 2 or more.

In group 2 were those who had endometriosis which of necessity required the infliction of more trauma than usual in the pelvis during operation to free up the pelvic organs and to remove the implants. There were 238 patients in this group.

In group 3 were those who had a value for hemoglobin of 70 per cent or less, there were 157 such patients. Fifty of these 157 anemic patients had a value for hemoglobin of 50 per cent or less.

In contrast to data obtained in these three groups are the data concerning the 1,497 "excellent risk" patients, with the incidence of thrombophlebitis, in Table I. In this table the tremendous increase in the incidence of thrombophlebitis among patients who had varicose veins is dramatically evident. Since varicose veins will not only keep the patients in bed days or weeks longer than usual, but will also expose them to the possibility of pulmonary embolism, it is obviously a serious factor to consider before operation. If surgical intervention is not urgently and immediately necessary, we strongly advise preoperative care of varicose veins. Such veins should be

treated by ligation or injection, or both, depending on the individual case.

In Table I also is shown the marked influence anemia has on the postoperative development of thrombophlebitis. As a whole, patients who have anemia are difficult to manage. Most extremely anemic patients bleed excessively and consequently their values for hemoglobin cannot be increased before operation to more nearly normal. The question of the effect of the transfusion of blood itself on the production of thrombophlebitis among anemic patients cannot be answered definitely at this time. Seventeen of the 157 anemic patients received transfused blood before operation or after operation from one to three times. Thrombophlebitis developed in only 1. Although it cannot be so stated with certainty on the basis of these figures, it seems reasonable to assume that it is far safer to transfuse blood to an anemic patient, if the indication arises, than it is to withhold blood because of the fear of producing thrombophlebitis. It might even be justifiable in these cases to resort to the preoperative prophylactic transfusion of blood.

In Table I the incidence of postoperative thrombophlebitis is shown to be about the same among obese patients (6.2 per cent) and among those who have endometriosis (5.9 per cent). The mechanism of the production of thrombophlebitis in these two groups of patients, however, probably is different. In the obese patient, slowing of the circulation because of lack of muscular action tends toward stagnation and formation of thrombi, whereas in the patient who has endometriosis, trauma to the iliac veins necessarily incident to the removal of pelvic implants is a more likely precipitating factor. Since the incidence of thrombophlebitis is roughly two to three times more frequent in these two conditions (6.2 per cent and 5.9 per cent, respectively) than in patients considered to be "excellent risks" (2.5 per cent) it would seem to be wise to seek active measures for the prevention of phlebitis among obese and anemic patients. In Table I it is also shown that the incidence of thrombophlebitis is almost doubled (4.7 per cent) when infection is found at the time of operation, as compared to the incidence of thrombophlebitis (2.5 per cent) when patients are considered to be "excellent risks."

## SITUATION

Thrombophlebitis occurred in the lower extremities in 75 per cent of the 99 cases. In practically all of the 25 per cent remaining thrombophlebitis probably also occurred in the leg, although this was not stated specifically in the records. Our

entire data are based on the clinical diagnosis of thrombophlebitis. No extra information obtained at necropsy has been included, other than confirmation of the cause of death.

In 30 per cent of the 99 cases, thrombophlebitis occurred in superficial varices or occurred in the form of mild attacks in the small or great saphenous vein. Elevation of the leg and hot applications were used for a few days, but none of these patients required postoperative support of the extremities for the prevention of swelling. Incidentally pulmonary embolism occurred only once in this group.

In 43 per cent of the 99 cases there was involvement of the femoral vein which may or may not have been associated with involvement of the iliac veins, or which may have constituted a severe attack involving the great saphenous vein. All patients in this group required elevation of the affected part and the application of large, hot, wet dressings during the acute phase and some form of support for a variable length of time after dismissal. The situation and extent of involvement in the remaining cases were not stated.

#### ONSET

The onset of thrombophlebitis varied from the 2d to the 25th postoperative day. In 75 per cent of cases the condition began between the 8th and 16th day after operation. More specifically in 55 per cent of cases thrombophlebitis occurred between the 9th and 14th days. In only 3 per cent of cases did thrombophlebitis occur before the 7th postoperative day. It is a known fact that thrombophlebitis may be fairly extensive without its being possible to diagnose it clinically. Consequently we have stated the day on which the condition was diagnosed, which may or may not be the day on which the condition began. Actually we believe that thrombosis occurs or at least begins, within the first 3 days after operation, and becomes evident only when muscular action causes symptoms to arise because of venous obstruction. Extension of the thrombosis also may be a factor in the clinical diagnosis.

#### PREVENTIVE TREATMENT

Proceeding on the assumption that by increasing the rate of venous return from the extremities we would be able to eliminate one of the essential factors in the production of postoperative thrombophlebitis, the following procedure was instituted for 2-6 patients recovering from gynecologic operations on the service of one of us (Counselier) for a period of roughly 4 months. All patients were included who required less than 7 days of rest

in bed after operation. Alternate patients from each day's list were used as controls. Because an odd number of patients underwent operation on different days, the number (146) of patients in the control group slightly exceeds the number (139) of patients on which the preventive treatment was based. In short, each alternate patient was placed in bed after operation and the legs were elevated immediately on pillows, so that the leg and forelegs were roughly 8 inches (20 cm) higher than the buttocks. A cradle containing two light bulbs (30 watts each) was placed over the legs in order to include the feet and part of the thighs. A cover (blanket, bedspread, or sheet) was then placed over the cradle. An ordinary thermometer was placed under the cradle and the temperature was maintained at 85 degrees F (29.4 C). This part of the procedure was the most difficult to carry out. It requires frequent inspection of the thermometer and the turning on and off of the light bulbs, as indicated. A thermostat would greatly simplify this problem. Most of the patients found the position and temperature at least tolerable; a few disliked it intensely and a few felt more comfortable under the cradle. An occasional patient was not included because of poor co-operation. In the control series of 146 patients the incidence of thrombophlebitis was higher (6 patients, or 4 per cent) than it was in the series of 30 treated patients (3 patients, or 3 per cent). Too much importance should not be attached to this observation, however, because closer analysis reveals that one less instance of thrombophlebitis in the control group and one more instance of it in the treated group could make the percentile incidence of thrombophlebitis practically the same for both groups. These figures are not statistically significant. Nevertheless this preliminary report indicates that a slight advantage was obtained by our efforts. It will require a considerably larger group of patients to prove our assumption definite.

#### SUMMARY

An analysis of thrombophlebitis, occurring after abdominal hysterectomy had been performed 2,654 times for benign conditions, has been presented. The occurrence of thrombophlebitis in another and separate group of 26 patients has been discussed. Patients among whom thrombophlebitis developed have been grouped according to the type of physical hazard they presented at operation, and according to the type of operation performed. On the basis of the incidence of thrombophlebitis in these different groups certain deductions have been drawn. A possible

method of lowering the incidence of thrombophlebitis has been presented

#### CONCLUSIONS

The incidence of postoperative thrombophlebitis is higher after subtotal abdominal hysterectomy has been performed than it is after total abdominal hysterectomy

The presence of varicose veins is the greatest single predisposing factor in the production of postoperative thrombophlebitis the incidence of thrombophlebitis being roughly ten times higher among patients who have varicose veins than it is

among patients who are considered to be "excellent risks"

Severe anemia increases the incidence about three times, and obesity, infection, and endometriosis increase the incidence approximately two times

The preoperative and postoperative transfusion of blood probably does not markedly increase the incidence of thrombophlebitis

Elevation of the legs and the application of constant dry heat after operation probably lower the incidence of thrombophlebitis in the lower extremities



# EDITORIALS

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JULY 1942

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### MILITARY MEDICAL INTELLIGENCE FROM RUSSIA

THE medical problems of modern warfare are obviously different from those encountered in the last great war in view of the predominant rôle of mechanized equipment and the ever increasing importance of the air arm in conjunction with the forces on land or sea. The campaigns of the last year on the Russian Front exemplify the most extensive fighting by modern arms that has yet taken place. The editors of SURGERY GYNECOLOGY AND OBSTETRICS have endeavored to obtain information from Russian sources concerning the medical problems with which the Russian Army has been faced in the last year. Information has indeed been fragmentary. However there follows a summary of several reports obtained from the Russian Embassy in Washington, D. C.

In spite of all difficulties and complexities of modern warfare it has been found possible to bring qualified medical aid within the maximum proximity to the front lines.

"Operations on intestinal and pulmonary organs are performed under the worst primitive conditions—in dugouts, tents, and huts. But even under these primitive conditions no departure from the fundamental requirements of antiseptic surgery is tolerated. Surgeons invariably operate in sterilized smocks, in gloves and masks with portable electric lamps and good instruments.

Dressings are sterilized on the spot by each medical battalion or traveling field dressing station. Autoclaves are set up usually in a dugout or small tent and maintain a steady supply of sterilized material day and night.

"Many lives have been saved, thanks to a splendidly organized blood transfusion service. Blood donated by all sections of the population and collected at stations set up in all rural and metropolitan communities is conserved in isothermal containers and sent by airplane and motor truck not only to the larger hospitals but to dressing stations located at the most advanced lines of the front. Shortage of blood for transfusion purposes has never been a problem since, if conserved blood is not at hand, donors are readily found among the medical personnel.

"There has been a sharp decline in incidence and mortality from anaerobic infections, attributed to early proper surgical treatment of infected wounds and the injection of prophylactic and curative serums. Tetanus is infrequent, this being in sharp contrast to the last World War.

"Since the Soviet counter offensive was launched amid severe winter conditions, considerable attention was paid to the prevention of frostbite among the evacuated. Such measures included heated ambulance cars, fur and

padded blanket bags improvised with padded dressings, extensive use of chemical heating pads, and frequent warming and feeding stations along the ambulance car routes. Men frostbitten during battle were immediately dispatched to field or rear hospitals for treatment. This was usually conducted by the 'open method with the help of physiotherapeutical apparatus.'

"The Red Army has widely developed a system of specialized medical aid. Wounds of the skull, eye, face, jaw, chest, and limbs—especially fractures of the thigh—are each treated in a special hospital. Even such apparently simple injuries as finger and wrist wounds are treated in special hospitals where the prime care is to restore the normal functioning of the damaged parts.

"In the hospitals for the treatment of light wounds in each army area—sometimes housed in dugouts, tents, cottages or huts—systematic treatment is given, including curative physical culture, the latter consisting of local and general gymnastic exercises, sports, and games. 'Labor therapy' for which special workshops are set aside, training, walking games, in the open air, and lastly military exercises, are all designed to render the lightly wounded fit for return to the ranks.

"In addition, hospitals for the lightly wounded are equipped with quartz lamps, paraffin baths, and other methods of heat treatment for facilitating absorption of infiltrations and swellings, and to speed regeneration of injured tissue. Special care is exercised to prevent chronic contractions, immobility of joints and other deformations that might make permanent invalids of the wounded.

"The 'functional cure' of limbs injured by firearms is widely practiced, employing, when necessary, plaster-of-paris dressings at proper intervals, and a regimen of alternating movement and rest.

"Regular conferences in base hospitals and at the front are held at which papers are read by eminent surgeons. In addition, younger surgeons present their own communications and demonstrations based upon their actual experiences in the field. The latter are summarized and analyzed and form an important basis for the development of the newer field surgery."

ALEXANDER BRUNSCHWIG

## THE SURGEON AT HOME MUST CONSERVE HIS STRENGTH

*"So Much To Do, So Little Time  
In Which To Do It"*

THESE words are attributed to Cecil Rhodes in the year of his death. They might be spoken today by every American surgeon. It is not my purpose to list the innumerable demands that are made upon our days and nights, for we are all fully aware of them. It is, however, my purpose to direct the reader's thought to the necessity of saving time, and to suggest ways and means whereby this can be done. The ordeal which lies ahead of us makes it imperative that we find ways to increase our efficiency. Surgeons who are in the military service will find that their schedule of activities is arranged for them. This editorial is not directed to them but to the members of the profession who have the task of carrying on at home. The demands that are going to be made upon our time will become increasingly heavy not only for the duration of the war but for some years thereafter. In speaking of the duration of the war let us for once be realists and admit the likelihood of its lasting at least five years more and probably seven. During this time the number of well trained surgical residents will not begin to fill the vacancies caused by death and incapacitating illness. It

bebooves us, therefore to look carefully into our use of time which is just another way of saying that we must give thought as to how we may conserve our individual strength.

The first suggestion that is offered is for us to recognize the unproductive activities that waste time. Are we making the maximum use of time saving devices,—the typewriter the dictaphone the portable telephone the air plane? How much do we now do that might be done equally well by a secretary or a technician?

Second, let us ask ourselves what are the circumstances that determine our activities? Is our day a work governed primarily by the sequence or the urgency of the demands made upon us or are we able to plan a schedule in advance? If the former is true then it follows that we are constantly working under pressure in a haphazard, harassing manner. To continue to do so during the next few years would be inexcusably stupid. On the other hand, if we are in the habit of planning our day's work, what are the usual sources of interference that wreck our plans? What can be done to protect ourselves from interruption? The answers to these questions must be worked out individually but one suggestion may be of help. In India the polite guest always waits for his host to rise first and thus indicate that the time has come for the guest to leave. This attitude is highly intelligent for how can a guest tell what his host wants to do? Might we not imitate this oriental custom and make it a habit to rise and plead an urgent call whenever our time is being wasted by an unimportant visitor? Of course we might have an agreement with the secretary to provide an appropriate interruption.

On a recent visit to the office of a certain Captain in the Medical Department of the Navy I was confronted by a large poster over the desk which read as follows:

# TIME ALLOWED IN THIS OFFICE FOR VISITORS

	Mins.	Secs.
Friends		
Friends with whom		
I share my business		
Contact men		
Salesmen		
All others		

Third all of us are guilty of a certain amount of lost motion. Part of every day is wasted because we sometimes move about awkwardly. The commonest cause for this is fatigue. Would it not be intelligent for us to follow the advice we give our patients when we tell them not to get tired out? Most of us become fatigued because we take on more than we can do easily. This is no time for doctors to make fools of themselves in their effort to serve their communities or the public at large. It is a time for them to say NO emphatically to every nonprofessional request that takes time or effort. We must conserve our strength for our work. Further more it is not enough to refrain from certain nonprofessional activities. Many of the surgeons in America might wisely limit the scope of their professional work as well. The physicians in a city in an eastern state are considering dividing the city into districts and confining their cases to their respective zones. Might not the efficiency of surgeons in many communities be enhanced if agreements could be reached whereby their operative cases were segregated in one or two hospitals? In England and on the Continent it has been necessary to assign doctors to certain districts and to force them to restrict their activities to the assigned area. The shortage of doctors for the civilian population in the United States may become so great that similar measures will have to be instituted but before such measures become mandatory it would be an intelligent move for many of us to set up self imposed restrictions. The present emergency

affords us an excellent opportunity to make the public realize that they must be as considerate in the demands they make on our time as they are in the demands they make on their attorney's time. People need to be taught that during the war doctors have no time to waste and that it is to their advantage to keep their own doctor from being exhausted through overwork.

Finally, it is imperative that surgeons give serious thought to the matter of their leisure time, first, to see to it that they have at least one period a week when they are inaccessible,

and second, to use that period wisely. How this is accomplished is a matter for each individual to settle for himself.

To sum up, the time has come when it is necessary to face the fact that all of us are going to have to do much more work than heretofore. To do this without physical and mental impairment it is necessary for us to scrutinize our use of time and to have the fortitude to make the necessary alterations in our activities. To fail to do so will certainly be foolish. It may be fatal.

WARFIELD M. FIROR

# MEMOIRS

JOHN M T FINNEY

1863 1942

JOHN MILLER TURPIN FINNEY who died at his home in Baltimore on May 30 1942 was born on a plantation near Natchez, Mississippi, on June 30, 1863. He was the son of Ebenezer Dickey Finney a Presbyterian minister and Anne Louise (Parker) Finney. After his mother's death, five months after his birth, he was taken into the family of Mrs. Stephen Turpin, a warm personal friend of his father and mother a granddaughter of Dr. John Archer the first graduate in medicine in this country. The Turpin in his name was inserted by his father in recognition of Mrs. Turpin's great kindness to him. Incidentally Mrs. Turpin was the first of his four foster mothers.

Dr. Finney was graduated from the College of New Jersey now Princeton University with the degree of A.B. in 1884, on his twenty-first birthday. He entered the Harvard Medical School and graduated in 1889, an extra year being necessitated by a severe attack of typhoid fever during his third year.

Following his graduation in Medicine he received an appointment on the resident surgical staff of the Massachusetts General Hospital where he came in intimate contact with Dr. C. B. Porter, Dr. John Humana, Dr. Arthur T. Cabot, and his life long friend and associate Dr. William S. Thayer.

On May 7 1889 the Johns Hopkins Hospital was opened and on that day Dr. Finney received from Dr. Halsted an appointment on the Surgical Staff in charge of the dispensary. That was the beginning of his long association with Johns Hopkins where he passed through various appointments until Dr. Halsted's death in 1923 when he was appointed acting professor of surgery and surgeon-in-chief to the hospital, which positions he held until he was succeeded by Dr. Dean D. Lewis, in 1935. On reaching the age of seventy in 1933 he was made emeritus professor of surgery.

In 1917 Dr. Finney went to France with Base Hospital No. 18 as its director, with the rank of Major in the Medical Corps. It was not long before he was appointed chief consultant in surgery of the A. E. F. with the rank of Colonel and later that of Brigadier General. His headquarters were at Neufchateau where he had under him the Chiefs of the Surgical Specialties. For his work in France he was awarded the Distinguished Service Medal, was made Commandeur de l'Ordre de la Couronne (Belgium) and Officier de la Legion d'Honneur (France).

He received many honors as a reward for his distinguished position in the



Painting by Thomas C. Comer

JOHN M T FINNEY

JUNE 20, 1863—MAY 30, 1942

# MEMOIRS

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He received many honors as a reward for his distinguished position in the

surgical world In 1927 he delivered the Hunterian Lecture before the Hunterian Society of London and was made an Honorary Member of the Society In 1932 he gave an address before the Boston Surgical Society and received the Bigelow Medal for "Achievement in Surgery" He was an honorary member of the Medical Society of London, the Royal College of Surgeons of England, the Royal College of Surgeons of Ireland, and the Royal College of Surgeons of Edinburgh Honorary L L D's were conferred upon him by Tulane University in 1935, by Harvard in 1937, and by Loyola College, of Baltimore, in 1940

He was one of the founders and the first president of the American College of Surgeons (President, 1913-1916, member of Board of Regents, 1913-1934, member of the Advisory Council of the Board of Regents 1937-1942), a member of the American Surgical Association (president, 1921), the Southern Surgical Association (president, 1912), the Medical and Chirurgical Faculty of Maryland (president, 1934-35), the Society of Clinical Surgery, and other medical societies From 1913 until his death Dr Finney was a member of the editorial board of SURGERY, GYNECOLOGY AND OBSTETRICS

For many years he had been keenly interested in education He was a trustee of Princeton University for some years and, when Woodrow Wilson became governor of New Jersey, he was offered the presidency of the University After much thought and consultation and on the earnest solicitation of the citizens of Baltimore, he decided to decline the invitation On his decision to remain in Baltimore, a large testimonial dinner was given in his honor at which a fund, which had been raised by his friends, was presented to the State Medical Society to be known as the "John M T Finney Fund for the Advancement of Surgery," the income to be used for lectures and the purchase of books and journals relating to surgery His interest in general education was manifested by the Boards on which he served In addition to being a life trustee of Princeton University, he was also a trustee of Lincoln University and the Princeton Theological Seminary At one time he was a member of the school board of Baltimore and until his death was a member of the State Board of Education and the president of the Boards of the Gilman School for Boys and McDonogh School

When he began to practice in Baltimore he was handicapped by the fact that he was given no privileges either in the public or private wards at the Johns Hopkins Hospital This made it necessary for him to seek other facilities where he could operate on his private patients He began to use the Union Protestant Infirmary and, as his practice grew, he became the outstanding member of the staff Finally, in 1919, he acted as the chairman of a campaign committee to raise funds for a new hospital, and it was largely through his efforts that the present Union Memorial Hospital developed as the successor of the old Infirmary He had had in mind for a long time that there should be some provision made for the hospital care of patients of moderate means, and whenever the opportunity



offered he would talk it over with his patients and friends. Finally one of his admiring patients Mr Frederick Bauernschmidt sent for him and told him that he was setting aside a considerable sum of money which he proposed to devote to the construction and equipment of such a building. On Dr Finney's advice he erected such a building in 1929 on the grounds of the Union Memorial Hospital, the first to be erected in this country for the care of people of moderate means. He confined his work largely to the Union Memorial Hospital and it was frequently spoken of as Dr Finney's Hospital.

Dr Finney belonged to that group often spoken of as Master Surgeons. He was pre-eminent and was familiarly called the 'King' by the house officers. His surgical judgment both as an operator and as a diagnostician was one of his outstanding qualities and his advice was eagerly sought by his colleagues in obscure and difficult cases.

As an operator he was at home in any field, but he was probably best known as an abdominal surgeon, being especially interested in lesions of the stomach and duodenum. For many years he advocated the operation of pyloroplasty which bears his name for duodenal ulcer. He was the author of numerous papers on surgical subjects and frequently took part in the discussions at medical and surgical meetings. In 1940 he published his autobiography *A Surgeon's Life*.

At the time of his death Dr Finney was looked upon as the first citizen of Baltimore. He was always interested in public affairs and served on many state and city commissions. He had been the chairman of the Community Fund and for the past few years, the chairman of the Baltimore Chapter of the American Red Cross. On two occasions he was mentioned as a candidate for Governor and for United States Senator both of which he declined.

As a man, his outstanding qualities were his integrity, his saneness, his loyalty and a forgiving nature which had their origin in his Christianity. These sterling qualities were illuminated by a social charm and a delightful sense of humor.

Dr Finney had a host of devoted friends. One of the closest, Dr George Walker conceived the idea of presenting to Dr Finney a parchment copy of Rudyard Kipling's poem 'IF' as he felt that Dr Finney so fittingly represented the qualities of manhood set forth in it. Dr Walker made a special trip to London to have Mr Kipling's autograph the copy. This was done forty-eight hours before Mr Kipling's death and was probably the last thing he signed.

This same friend Dr Walker died within a few months and left his entire estate—a considerable one—to establish the Finney Howell Research Foundation for the Investigation of Cancer.

Dr Finney always took a lively interest in sports of many kinds. As a student at Princeton he played on the Varsity football team and while at the Harvard Medical School he also played on the Varsity team of that institution—the only instance in which a man played on both the Princeton and the Harvard Varsity

teams He was always an enthusiastic supporter of the athletic activities of his Alma Mater He was fond of hunting and fishing, and in Nova Scotia, where he spent his summers, he waded many of its rivers in pursuit of salmon

He is survived by his widow, Mary E Gross Finney, two sons who are surgeons, John M T Finney, Jr , and George Gross Finney, a third son Eben Dickey Finney, an architect, and a daughter, Mrs James S McDonnell

To all who knew him personally or by reputation, Dr Finney was the ideal physician, selfless in his devotion to his profession, inspiring younger men by his ability, and by his unfailing service to all of his patients, regardless of race, creed, or station in life In his death the medical profession has lost one of its most distinguished and beloved members, and the Country a valuable and loyal citizen

WILLIAM A FISHER

# THE SURGEON'S LIBRARY

## REVIEWS OF NEW BOOKS

THE author of *The Microbe's Challenge*<sup>1</sup> is a man with evident knowledge and understanding of his subject and exceptional writing ability. Designed for the intelligent reader its simplicity and clarity of expression are without condescension. Unlike most books written for the laity the substance is not neglected for the spectacular and arresting. The style is simple without sacrifice of exactness, dignified yet leavened and animated by intriguing chapter headings and pithy phrases. Microbiology is treated as a dynamic branch of science, in its relation to agriculture, industry and particularly to disease and public health. The discoveries and advances and great gains in prevention of disease are entertainingly and accurately described still it is made clear that the problems ahead are many. The defenses elaborated against them the microbes present, through their adaptability an ever changing front as challenge to man's supremacy. This is the theme of the story. This book may be recommended unhesitatingly to the lay reader attracted to science, as an interesting and informative one and also to the microbiologist, physician, or public health worker who will in addition find it provocative. A. A. DAY

THE author of *The Modern Treatment of Syphilis*<sup>2</sup> has provided an appraisal of accomplishments in syphilotherapy since 1903 and comprehensive presentation of modern treatment methods. The monograph is based largely on studies made in the syphilis division of Johns Hopkins Hospital and on the contributions of the Co-operative Clinic Group composed of chiefs of the Syphilis Clinics of the University of Pennsylvania, the May Clinic, the University of Michigan, Western Reserve University, Johns Hopkins University and of representatives of the United States Public Health Service.

Recent appreciation of the prevalence of syphilis and the importance of its control as part of national defense has created greater desire in the general practitioner as well as in the specialist, to be familiar with the latest developments and the most approved treatment methods. That the author had the needs of the general practitioner in mind is evident by the directness of presentation. While the statistical approach is used, since Dr. Moore believes the most reliable decisions are based on the average response

of a large group, the text is interesting as well as convincing.

In the second edition, 23 of the 31 original chapters have been added, one dealing with the public health and one with the massive arsenotherapy. Of special interest to those familiar with the first edition will be the chapters on the interpretation of serologic tests in diagnosis and treatment control, on the treatment of cardiovascular involvement, and on the prevention of prenatal syphilis. An entire chapter is devoted to the consideration of the ever recurring questions of infectiousness, prognosis, and cure.

In the chapter devoted to public health, attention is called to the fact that syphilis is the only major infection in which the spread can be controlled only by treatment of the infectious patient and by no other method. It is stated that this fact has accelerated the growth of free clinics since half of the infectious individuals cannot pay for any part of their medical care, and a large proportion of the remainder can contribute only a small fraction of its cost. It is stated that syphilis constitutes a challenge to physicians and public health officials, demanding the most intelligent thought and utmost effort.

The chapter dealing with the intensive arsenotherapy reflects a most conservative, but open-minded approach to the subject. Regret is expressed that fundamental laboratory data concerning the "five-day" treatment were not accumulated before the method was tried clinically. The author states, however, that if it can be established that this method of treatment can accomplish as much in 5 to 30 days as is now accomplished in 3 months by the standard treatment and with no greater risk to the patient, it will be the greatest advance in syphilotherapy since the discovery of arsenphenamine.

Each chapter is followed by a well selected bibliography on all important points with particular emphasis on recent publications. This book is highly recommended, both as a manual for the specialist and as a textbook for the practicing physician.

BURTON SHAW

IN a treatise of 400 pages on the subject of toxemia of pregnancy the authors have attempted to cover this subject from its earliest history reviewing the trend in its development particularly that relating to the early treatment this with a comprehensive review of the important research that has

<sup>1</sup>THE MICROBE'S CHALLENGE. By Frederick Eberhart, Ph.D. M.D. LANCASHIRE, PENNSYLVANIA: The Japan Cellulose Press, 1941.

<sup>2</sup>THE MODERN TREATMENT OF SYPHILIS. By Joseph Earle Moore, M.D. with the collaboration of Gerald K. Kamp, M.D., and Joseph M.D. Fred Probst, M.D. and Mary E. Anderson, M.D. ed. Springfield, Ill., and Baltimore, Md. Charles C. Thomas, 1941.

# REVIEWS OF NEW BOOKS

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been done in relation to this subject, and a report of their own studies on a series of 80 patients comprise the contents of this work.

Edema and its manifestations in normal pregnancy and in toxemia is the first subject considered. One hundred patients with generalized edema and 100 patients without generalized edema in pregnancy constitute the material from which their observations in regard to this phase of toxemia were made. Observations and other studies are described and the findings summarized. The importance of the appearance of generalized edema in pregnancy is stressed. Various possible etiological factors are discussed and the chapter on this subject closes with the statement that "by exclusion, a primary humoral etiology is suspected."

The relation of the pressor fraction of the posterior pituitary to the hypertension of toxemia of pregnancy is the next subject considered in this volume. References to the experimental work of other investigators are stated and this is followed by the experimental work of the authors in which they present the data obtained by the administration of pitressin in single and multiple doses to test animals. They were unable to produce a permanent hypertension in rabbits by this substance. The toxic effects of pituitary substance is emphasized and some cases of collapse following its administration are cited. Similar studies on placental extracts with the idea of demonstrating the presence or absence of a pressor substance in the placenta resulted in negative values.

Hormonal injections into test animals failed to have any effect upon their blood pressure or urine. One third of the volume is devoted to a discussion of pre-eclampsia and eclampsia in which the authors present the results of their observations on 80 patients who manifested symptoms of this condition. All phases of the condition are discussed and frequent references are made to the work of other investigators. This chapter closes with a hypothesis—another hypothesis, naming the placenta as the offending factor in the production of the group of symptoms called toxemia of pregnancy. However, no evidence is offered in support of such a hypothesis.

The remainder of the volume consists of the various forms of treatment that are employed in the control of toxemias. The methods employed in the of the foremost obstetrical institutions are presented in detail and other methods are discussed. From a practical point of view this book will be of little value to the general practitioner or medical student, however its value to anyone especially interested in the toxemias of pregnancy must be emphasized for it has one of the best bibliographies on this subject to be found anywhere.

CHESTER C. DOWRY

THE new and greatly enlarged second edition of *The Autonomic Nervous System* is a worthy successor to the eminently successful first edition of

THE AUTONOMIC NERVOUS SYSTEM. ANATOMY, PHYSIOLOGY AND SURGICAL APPLICATION. By JAMES C. WHITE, M.D. and REGINALD H. SMITH, M.D. 2d ed. New York: The Macmillan Co. 1941.

1935. In fact, this monograph is so largely rewritten and so many new subjects are presented that it is more like a first edition.

There is one ready source where the anatomy, physiology, pharmacology, and surgical treatment of the autonomic nervous system may be found in a concise accurate, even "simplified" form. Much of the book is solidly factual, and this material is obviously not meant to be used for continuous reading, but rather for specific reference. The running text, however, makes most interesting reading, for the style is constantly referred to. This book is highly informative and practical in its application, and while the opinions and results of many investigators are given, they are wisely presented by the authors at their face value, for the rapidly changing status of our information concerning the autonomic during the past few years indicates the necessity for guard against overenthusiasm for "new discoveries."

This book rightly deserves wide publicity and use for several reasons. It honestly sets forth the beliefs not only of the authors, whose experience in investigative work on the autonomic nervous system is well known, but also the results of research of many other investigators of tested reliability. The present day concept of the physiology of the hypothalamus and midbrain in its practical application is presented in interesting, easily understood form. The physical arrangement of the book makes it useful not only as a reference for the investigator or surgeon, but also as a text for the advanced medical student. The simple, clear line drawings and charts are a fortunate addition to the text, and the extensive, up to date bibliography alone makes the book well worth owning.

JOHN MARTIN

THE 10th edition of *Diseases of Women* by Crossen devotes 100 pages to the anatomy and physiology of the pelvic organs. Physiology predominates, which is in keeping with the trend of gynecology at the present time. The discussion of the endocrines and the ovarian and endometrial relationship is timely, concise, simply worded, and readily understood. It is an excellent summary of our present day knowledge and is valuable for the practitioner as well as the student. Vaginal smear studies are thoroughly described.

Minute details of gynecological history taking and examination, which are essential for the establishment of an accurate diagnosis, are stressed. The gynecological treatment measures are described in a separate chapter. This makes the book valuable as a readily available reference on the recent methods of management.

A considerable portion of the book is devoted to the diseases of the external genitals and vagina. The chapter dealing with cancer of the uterus is particularly good.

DISEASES OF WOMEN. By Harry Sturgeon Crossen, M.D., F.A.C.S. and Robert James Crossen, A.B. 10th ed. St. Louis: The C.V. Mosby Co. 1941.

Medicological points in gynecology are included which is a unique feature of this book.

One of the most important considerations in the book is the discussion and the many gross photographs and photomicrographs of the pathological theses. The excellent handling of this subject makes

the book rate as an excellent treatise on gynecological pathology.

The numerous figures, which number 117 and the extensive bibliography suit this book to the needs of all who are interested in gynecology.

HUGO O. JONAS

## BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

UROLOGICAL DISEASES OF PREGNANCY. By E. Graville Crabtree, M.D. Boston Little, Brown & Co. 942.

THE BOND BETWEEN US: THE THIRD COMPONENT. By Frederic Loomis, M.D. New York Alfred A. Knopf. 943.

THE HISTORY AND EVOLUTION OF SURGICAL INSTRUMENTS. By Dr. C. J. S. Thompson. New York, Schuman, 942.

BOLETIN DEL INSTITUTO DE CLINICA QUIRURGICA, OCTUBRE DICIEMBRE, 94. Buenos Aires Universidad de Buenos Aires. 941.

SURGICAL PHYSIOLOGY. By Joseph Nash, M.D. Springfield, Ill., and Baltimore, Md. Charles C. Thomas. 942.

QUINTOS HED TINCOS DEL RAZO. By Clemente J. L. Morel. Buenos Aires El Ateneo. 942.

SYNOPSIS OF ANO-RECTAL DISEASES. By Louis J. Hirschman, M.D. F.A.C.S. 2d ed. St. Louis The C. V. Mosby Co. 94.

CARCINOMA AND OTHER MALIGNANT LESIONS OF THE STOMACH. By Walther Walther, B.S. M.D. M.S. (Surg.), D.Sc., F.A.C.S., Howard K. Gray B.S., M.D. M.S. (Surg.) F.A.C.S. and James T. Priestley B.A. M.D. M.S. (Ex per Surg.) Ph.D. (Surg.) F.A.C.S. Philadelphia and London W. B. Saunders Co., 1943.

PATHOLOGY OF THE ORAL CAVITY. By Lester Richard Cahn, D.D.S. Baltimore The Williams & Wilkins Co. 94.

O PNEUMONIA EXTRA-PLEURAL. By Enryelides de Jesus Zerbini. 2d ed. São Paulo Revista de Cirurgia de São Paulo. 941.

OVER-LOOKING URGENCIES. By W. Tejerías Forthingham Vols. and Buenos Aires El Ateneo, 1941.

THE PRINCIPLES OF ANATOMY AS SEEN IN THE EYE. By Frederic Wood Jones, D.Sc. (Lond. Adelaide and Melbourne) F.R.S., F.R.C.S. 2d ed. Baltimore The Williams & Wilkins Co., 943.

VASCULAR SCHEMES, WITH SPECIAL REFERENCE TO ANTERIOCORONARY PATHOLOGY, P. THORNTON, ESQ., M.D. DIAGNOSIS, PROGNOSIS, TREATMENT. By F. H. Mackenzie, A.B. M.D. London, New York, and Toronto Oxford University Press, 942.

DEBILITY: E. ALFARON. PRINCIPLES OF TREATMENT OF CONSIDERABLE IMPORTANCE. By Earl D. McBride, B.S., M.B. F.A.C.S. 2d ed. Philadelphia, London, and Mexico J. B. Lippincott Co. 942.

A STUDY OF THE BLOOD IN CANCER WITH SPECIAL REFERENCE TO THE NEEDS OF THE TISSUE. CIRC. By O. Cameron Greiner M.D. (Lond.). Montreal Royal Publishing Co. 943.

AN OLD DOCTOR OF THE NEW SCHOOL. By James C. Wood, M.D. Caldwell, Idaho The Carson Printing Lab. 942.

HISTORY OF THE SCHOOL OF NURSING OF THE PRINCE GEORGE HOSPITAL, NEW YORK, 1892-1942. By Emma Lee, A.B. R.N. New York G. P. Putnam's Sons. 1942.

ACUTE INJURIES OF THE HEAD, THEIR DIAGNOSIS, TREATMENT, COMPLICATIONS AND SEQUELAE. By G. I. Rowbotham, B.Sc. (Medicine), F.R.C.S. (Hon.) with Foreword by Norman M. Dott, M.B. Ch.B. (Ed.) F.R.C.S. (Ed.) Baltimore The Williams & Wilkins Co., 1943.

ARCHITECTURAL PRINCIPLES IN ANTERIOR. By H. L. Brittain, M.A. M.Ch. F.R.C.S., with Foreword by Henry Platt, M.D. M.S. F.R.C.S., F.A.C.S. (Hon.) Baltimore The Williams & Wilkins Co., 942.

UROLOGY IN WAR: WOUNDS AND OTHER EMERGENCIES OF THE GENITO-URINARY ORGANS, SURGICAL AND MEDICAL. By Charles J. Bidgood, Lt. Colonel (MC) U.S.A. Baltimore The Williams & Wilkins Co. 1942.

# CLINICAL CONGRESS OF AMERICAN COLLEGE OF SURGEONS

W EDWARD GALLIE, Toronto, *President*

IRVIN ABELL, Louisville, *President-Elect*

*Committee on Arrangements*

WARREN H COLE, *Chairman*, MARSHALL DAVISON, *Secretary*

## 1942 CLINICAL CONGRESS IN CHICAGO—A WAR SESSION

TO DEAL adequately with the many medical and surgical problems arising out of the prosecution of an all out effort to win the war, emphasizing the needs of the rapidly expanding medical services of the Army and Navy, and consideration of special problems related to the increasing activities for civilian defense, a program for the thirty-second annual Clinical Congress of the American College of Surgeons, to be held in Chicago, October 19-23, is being developed under the direction of the Board of Regents. These ideas will highlight the program for scientific sessions at headquarters and provide the basis for many clinical demonstrations at the hospitals.

The surgeons of this great medical center have organized and plan to present a program of operative clinics and demonstrations that will provide a comprehensive showing of their clinical activities in all departments of surgery at the four medical schools and some forty hospitals that will participate in the program. Under the leadership of a committee of well known surgeons, representative of the interests of all surgical specialties, a complete and varied program is assured for all who will attend this year's Congress. The five-day program will include a presentation of the latest advances in diagnostic methods, surgical technique, operative procedures, and the after-care of the surgical patient. A preliminary schedule of the clinical programs at a number of the hospitals, prepared at the direction of the Committee on Arrangements, appears in the following pages, which schedules are to be revised and amplified during the months preceding the Congress. It will be noted that clinics and demonstrations will be held at the hospitals on the afternoon of Monday, October 19, and the mornings and afternoons of each of the succeeding four days.

### EXECUTIVE COMMITTEE

Warren H Cole, Chairman  
Marshall Davison, Secretary  
Fred L Adair  
George L Apfelbach  
William J Baker  
Frederic A Besley  
Alexander Brunschwig  
James J Callahan

Edward L Compere  
Sumner L Koch  
Francis L Lederer  
Samuel J Meyer  
Oscar E Nadeau  
Eric Oldberg  
Willard Van Hazel  
John A Wolfer

Two important features of the program for the Congress—a symposium on fractures and other traumas, and a symposium on cancer—will be presented on Tuesday and Wednesday afternoons.

### PRESIDENTIAL ADDRESS—CONVOCATION

At the Presidential Meeting and Convocation, on Monday evening in the ballroom of the Stevens Hotel, the new officers of the College will be inaugurated, and the initiates received into fellowship. The new officers are Irvin Abell, Louisville, President, Leland S McKittrick, Boston, First Vice President, F Phinzy Calhoun, Atlanta, Second Vice President. Distinguished surgeons from foreign countries will be introduced, following which Dr W Edward Gallie, of Toronto, will deliver the presidential address.

Major General James C Magee, Surgeon General of the Army, Rear Admiral Ross T McIntire, Surgeon General of the Navy, and Colonel George Baehr, M C, U S A, Chief Medical Officer of the Office of Civilian Defense have been invited to deliver addresses at this session.

### PANEL DISCUSSIONS ON WAR SURGERY

The value of the panel discussion as a medium of conveying information on selected subjects has been amply demonstrated in previous Clinical Congresses, sectional meetings, and the "war sessions" that have been held throughout the country during the present year. The Board

of Regents has deemed it wise to use this medium as the principal method for the presentation of subjects at the headquarters for the 942 Congress. The master panels will be held on each afternoon Monday through Friday and on Wednesday and Thursday evenings.

The restriction of the program to subjects dealing directly with war surgery has made it desirable to arrange these panel discussions, so that they will be held consecutively rather than synchronously. This arrangement will enable all attending the Congress to be present at all of the panel discussions, as every surgeon will wish to do. They will be held in the ballroom of the Stevens Hotel, which will amply accommodate the members of the Congress.

Eminent civilian and military surgeons and physicians will collaborate in all of the panel discussions and opportunity will be afforded for questions from the floor. Among the speakers will be surgeons who have actually participated in the military services during the present war. Arrangements are being made for the discussion of the following subjects: Recognition and treatment of shock, treatment of burns, fractures, and wounds of the chest, skull, face and other soft parts.

At one of the panels especial attention will be directed to the procedures adopted by the medical corps of the Army and Navy in the transportation of the wounded and their treatment at the various types of hospitals and stations established by the military services, as well as aboard airplanes and ships.

On Tuesday evening, in addition to the panel discussions, the annual oration on surgery will be delivered and certain medical aspects of the war will be presented by representatives of the federal services on the subjects of tropical medicine, acute infectious diseases, venereal disease and gynecology and obstetrics in their relation to the war.

#### CLINICAL PROGRAM

The clinical programs for the hospitals and medical schools will be arranged to cover subjects in general surgery, obstetrics and gynecology, fractures and other traumas, thoracic surgery, neurosurgery, otology, orthopedic surgery, ophthalmology and otolaryngology. Under these classifications the presentations will be so correlated that the visiting surgeon will have an opportunity to devote his time continuously to those clinics dealing with the specialty in which he is most interested. The complete detailed clinical program for each day will be posted in the form of bulletins at headquarters at the Stevens Hotel

during the afternoon of the preceding day and distributed in printed form each morning.

#### FORUM ON FUNDAMENTAL SURGICAL PROBLEMS

A feature introduced at the 1931 Clinical Congress in Boston where it met with great favor was the "Forum on Fundamental Surgical Problems." It will have an important place in the program for the 1942 session. Plans are being formulated by a committee under the chairmanship of Dr. Owen H. Wangensteen of the University of Minnesota. The purpose of this forum is to enable younger men, representing various university departments of surgery, to present the important results of their clinical and experimental research work before a large surgical meeting. As heretofore there has been limited opportunity for these younger men, many of whom have not yet qualified for membership in the principal surgical societies, to present their original work and ideas. As surgery is concerned today not only with anatomy and pathology but also with physiology, chemistry and physics, it is felt that the Clinical Congress program will be broadened by the presentation of the best of this material, so that the surgeons attending the Congress may benefit therefrom. Presentations of original experimental work will relate to surgery and the surgical specialties. There will be no prepared discussions but an opportunity will be afforded those in attendance to ask questions. Presentations will be limited to ten minutes each and it is expected that some of the best examples of new and highly constructive developments in surgery will be presented. There is every indication that a lively and active surgical forum in which the younger men may participate will constitute an important activity of the Congress.

#### SURGERY OF THE EYE, EAR, NOSE AND THROAT

The general program of the Congress includes many features of special interest to those surgeons whose practice is limited to ophthalmology and otolaryngology. In addition to extensive schedules of clinics and demonstrations in surgery of the eye, ear, nose and throat, to be given daily at the hospitals, programs are in preparation for a series of clinical conferences on Tuesday, Wednesday and Thursday mornings at headquarters, at which subjects of timely interest to these specialists will be discussed in small groups under the leadership of outstanding men, providing an opportunity for all in attendance to ask questions and participate in the discussions. For Tuesday and Wednesday evenings programs are being prepared for scientific sessions, including

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papers and symposia on pertinent subjects. Preceding each morning and evening session there will be an exhibition of selected motion picture films on subjects related to these special fields.

## HOSPITAL STANDARDIZATION CONFERENCE

At the opening session of the twenty-fourth annual Hospital Standardization Conference, at 10 o'clock on Monday morning, Dr W Edward Gallie, of Toronto, presiding, the 1942 list of approved hospitals, cancer clinics, and hospitals approved for graduate training in surgery and the surgical specialties will be officially announced. Representatives of the Medical Corps of the Army and Navy, Office of Civilian Defense, Procurement and Assignment Service, Selective Service, and the Army Nurse Corps, are being invited to participate in this program.

The hospital conference will continue on Monday afternoon and on the mornings and afternoons of the following three days. Programs are being prepared that will be of interest to hospital administrators, heads of various hospital departments and their personnel, nurses, and members of the governing boards.

As a special feature of the conference it is planned to develop a program that will appeal to the general surgeon and surgical specialists. For some of the sessions the programs will consist of formal papers, while others will assume the nature of panel discussions, round-table conferences, and open forums. At certain sessions specific phases of a general theme will be presented by several speakers, in others a variety of subjects will be covered, the program being developed to meet current needs, emphasizing the rôle of the hospital in the program of national defense.

## SCIENTIFIC EXHIBITS

Arrangements are being made for a limited display of scientific exhibits to be placed in the lounge on the second floor of the hotel, adjacent to the ballroom. The committee in charge of the exhibits is planning that they shall for the greater part illustrate subjects which will be discussed at the scientific meetings. As in the other features of the Congress, it is expected that these exhibits will have a direct bearing on surgery as practiced in wartime and on measures for civilian defense. Exhibits by various departments of the College will present what amounts to up-to-date reports on the scope and progress of the work.

## GRADUATE TRAINING IN SURGERY

The College program for graduate training in surgery and the surgical specialties, as it may be

affected by wartime conditions, will receive special attention at this Congress. Various phases of this important activity of the College will be presented for discussion by surgeons, hospital executives, and educators who are concerned with the future standard of surgery in the United States and Canada. A program dealing with various types of educational programs will be presented, followed by a general discussion from the floor.

## MEDICAL MOTION PICTURES

An enlarged program of surgical motion pictures will be presented daily at headquarters and will include the latest available films on a wide variety of subjects of interest to the surgeon—both sound and silent, standard and color films, that have been approved by the Committee on Medical Motion Pictures, will be presented.

## PUBLICATION OF PROCEEDINGS

As in former years, the papers which are presented at the scientific sessions of the Congress will be published in a special issue of the official journal of the College, *SURGERY, GYNECOLOGY AND OBSTETRICS*, in February following the meeting. This is furnished without additional charge to all fellows, junior candidates, and others who register for the Congress as invited guests. The papers which are presented in connection with the Hospital Standardization Conference will be published in subsequent issues of the *Bulletin of the American College of Surgeons*.

## ADVANCE REGISTRATION

The hospitals and medical schools of the Chicago area afford accommodations for a large number of visiting surgeons, but to insure against overcrowding, attendance at the Congress will be limited to the number that can be comfortably accommodated at the clinics. The limit of attendance will be based on a survey determining the available facilities in the participating hospitals and schools. It is expected, therefore, that surgeons who wish to attend the Congress will register in advance.

As in previous years, admission to clinics and demonstrations in the hospitals and certain of the scientific meetings at headquarters will be controlled by means of tickets. This plan provides for the distribution of visiting surgeons at the various clinics and other meetings and helps to insure against overcrowding. The number of tickets issued for any clinic will be limited to the capacity of the room in which the clinic is held. Visiting surgeons are urged to co-operate in making the clinic ticket plan a success.



## REGISTRATION FEES

Resolutions adopted by the Board of Regents provide that no registration fee for the 1932 Clinical Congress, is to be paid by fellows of the College including Initiates of the class of 1932. The fee for endorsed junior candidates is \$5.00 and for surgeons, not fellows attending as invited guests of the College, \$10.00. For purposes of identification at the registration desk fellows will present their fellowship cards.

When the registration fee is paid in advance a formal receipt will be issued to the surgeon so registering which is to be exchanged for a general admission card upon presentation at headquarters during the Congress. This card is not transferable and must accompany all requests for clinic tickets and be presented for admission to scientific sessions when required.

## HEADQUARTERS—TECHNICAL EXHIBITION

Headquarters for the Congress will be established at the Stevens Hotel, which affords unusual facilities for accommodating the Congress. All the public rooms on the second and third floors and ballrooms in the tower have been reserved for scientific sessions, panel discussions, conferences, and scientific exhibits. Thus all activities of the Congress, except the clinics at the hospitals, will be held in one building.

The technical exhibition together with the registration and clinic ticket desk, will be located

on the lower floor of the hotel in the large exhibition hall, where the daily clinical program is posted in the form of bulletins. Leading manufacturers of surgical instruments and supplies, sutures, dressings, pharmaceuticals, operating room equipment, x-ray apparatus and hospital equipment of all kinds, as well as publishers of medical books will be represented in the exhibition. It will provide for the visiting surgeon an opportunity of carefully inspecting the latest modern products of all these industries before aiding the work of the surgeon and the hospital.

## CHICAGO HOTELS AND THEIR RATES

In addition to the headquarters hotel, the Stevens, there are several first-class hotels within walking distance of headquarters, providing ample hotel facilities at reasonable rates. It is suggested that reservation of hotel accommodations be made at an early date. The following hotels are recommended by the Committee

	Rooms per week by	
	Single	Double
Bismarck, 7 W. Randolph St.	\$3.75	\$6.75
Blackstone, Michigan Ave. & 7th St.	4.00	7.00
Congress, 500 S. Michigan Ave.	3.00	5.00
Drafts, Michigan and Lake Shore Dr.	4.00	6.00
Harriett, 57 E. Harrison St.	5.00	8.00
LaSalle, N. LaSalle St.	7.00	10.00
Morrison, 79 W. Madison St.	7.00	10.00
Palmer House, S. F. Monroe St.	5.75	9.75
Sherman, 206 W. Randolph St.	7.00	10.00
Stevens, 720 S. Michigan Ave.	4.25	7.25

# PRELIMINARY CLINICAL PROGRAM

## COOK COUNTY HOSPITAL

### Monday

GENERAL SURGERY  
 RICHARD H LAWLER—2 Operative clinic.  
 OBSTETRICS AND GYNECOLOGY  
 A F LASH—1 Operative clinic Gynecological  
 FRACTURES AND OTHER TRAUMAS  
 WILLIAM R CUBBINS, JAMES J CALLAHAN, and CARLO S  
 SCUDERI—1 Operative clinic  
 ORTHOPEDIC SURGERY  
 E J BERKHEISER—2 Dry clinic.  
 NEUROSURGERY  
 HAROLD C VORIS—1 Operative clinic  
 OTOLARYNGOLOGY  
 COB LIFSCHUTZ—2 Operative and dry clinic.

### Tuesday

GENERAL SURGERY  
 GEORGE G DAVIS—8 Operative clinic  
 KARL A MEYER and RAYMOND W McNEAL—9 Oper-  
 ative clinic  
 STANLEY L KOCH—9 Dry clinic Injuries of the upper  
 extremities  
 JOHN D KOVACKY—10 Operative clinic  
 JOHN R HARGER—10 Operative clinic  
 EDWIN M MILLER and E H FELL—10 Dry clinic  
 JOHN B O'DONOGHUE—11 Operative clinic  
 RALPH B BETTMAN—2 Operative clinic  
 PETER A ROSI—2 Operative clinic Large bowel and  
 rectum  
 E H WARSZEWSKI—3 Operative clinic.  
 COOK COUNTY GRADUATE SCHOOL OF MEDICINE  
 Staff—12 30 Demonstration on cadaver, some principles  
 in gall bladder surgery

OBSTETRICS AND GYNECOLOGY  
 WILLIAM T CARLISLE—9 Operative clinic Gyneco-  
 logical  
 A E KANTER—11 Operative clinic Gynecological  
 J P GREENHILL—1 Operative clinic Gynecological  
 ORTHOPEDIC SURGERY  
 ARTHUR H CONLEY—9 Operative clinic  
 MARCUS H HOBART—10 Operative clinic Knee opera-  
 tion  
 OPHTHALMOLOGY  
 EDWARD A ROLING—9 Operative clinic.

### Wednesday

GENERAL SURGERY  
 WILLIAM M McMILLAN—8 Operative clinic.  
 A CHRISTOFFERSON—9 Dry clinic.  
 ANK J JIRKA—10 Dry clinic Human bites of the hand  
 ER T VAUGHAN—10 Operative clinic.  
 B R BUCHINDER—1 Operative clinic.

Staff—2 Symposium Traumatic surgery  
 SUMNER L KOCH Treatment of fresh accidental wounds  
 WILLIAM R CUBBINS Management of compound frac-  
 tures  
 HARRY A OBERHELMAN Gunshot wounds of the abdo-  
 men  
 ADRIEN VERBRUGGHEEN Management of acute head in-  
 juries  
 LINDON SEED Gunshot wounds of the chest  
 HUGH O BROWN Anesthesia under wartime conditions  
 COOK COUNTY GRADUATE SCHOOL OF MEDICINE  
 Staff—12 30 Demonstrations in gastric surgery on the  
 cadaver and anesthetized dog

OBSTETRICS AND GYNECOLOGY  
 HERBERT E SCHMITZ—9 Operative clinic Gynecological  
 A F LASH—11 Operative clinic Gynecological  
 DAVID S HILLIS, JAMES H BLOOMFIELD, JAMES E FITZ-  
 GERALD, LOUIS RUDOLPH, ALFRED J KOBAR, and AV-  
 OUST DARO—1 Obstetrical operations and discussion,  
 cephalopelvic disproportion in 1000 consecutive cases  
 FRACTURES AND OTHER TRAUMAS  
 JAMES J CALLAHAN—8 Ward walk  
 GEORGE L APPELBACH—10 Operative clinic

ORTHOPEDIC SURGERY  
 PHILIP LEWIN—9 Operative clinic  
 DANIEL H LEVINTHAL and associates—9 Dry clinic  
 DANIEL H LEVINTHAL and associates—2 Operative clinic  
 GENITOURINARY SURGERY  
 HARRY C ROLNICK and ANDREW McNALL—8 Opera-  
 tions  
 HARRY CULVER and DORRIN F RUDNICK—9 Operations

NEUROSURGERY  
 HAROLD C VORIS—9 Dry clinic  
 ADRIEN VERBRUGGHEEN—1 Operative clinic  
 OPHTHALMOLOGY  
 WILLIAM F MONCREIFF—9 Operative clinic  
 OTOLARYNGOLOGY  
 JACOB LIFSCHUTZ—2 Operative clinic

### Thursday

GENERAL SURGERY  
 HARRY A OBERHELMAN—8 Operative clinic  
 MAX THOREK—9 Operative clinic  
 MARSHALL DAVISON—10 Operative clinic  
 JOSEPH E SCHAEFER—10 Operative clinic  
 Staff—11 Clinical pathological conference  
 E J LEWIS—1 30 Operative clinic  
 COOK COUNTY GRADUATE SCHOOL OF MEDICINE  
 RAYMOND W McNEAL—11 Lecture on femoral hernia  
 OBSTETRICS AND GYNECOLOGY  
 E W FISCHMAN—9 Operative clinic

FRACTURES AND OTHER TRAUMAS  
 JAMES J CALLAHAN—8 Ward walk  
 WILLIAM R CUBBINS—1 Operative clinic

## ORTHOPEDIC SURGERY

ARTHUR H. COOLEY—*a.* Dry clinic.  
E. J. BERCHENGER—*s.* Operative clinic.

## THORACIC SURGERY

RALPH B. BETTMAN—*s.* Operative clinic.

## NEUROSURGERY

ANDREW VALENTUOGHI—*s.* Dry clinic.

## Friday

## GENERAL SURGERY

RALPH C. SULLIVAN—*s.* Operative clinic.  
EDWIN M. MILLER—*s.* Operative clinic.  
LOUIS P. RIVER—*s.* Operative clinic.  
ALBERT H. MONTGOMERY—*a.* Operative clinic.

## OBSTETRICS AND GYNECOLOGY

WILLIAM H. BROWNE—*s.* Operative clinic.  
FREDERICK H. FALLS—*a.* Operative clinic.

## FRACTURES AND OTHER TRAUMAS

JAMES J. CALLAN—*s.* Ward walk.

## COOK COUNTY GRADUATE SCHOOL OF MEDICINE

Staff—*js.* Demonstrations on cadaver fractures and traumatic surgery

## THORACIC SURGERY

RICHARD M. D. VERN—*s.* Operative clinic.

## NEUROSURGERY

HAROLD C. VORSE—*s.* Operative clinic

## ORTHOPEDIC SURGERY

SAMUEL R. GIFFORD—*s.* Operative clinic.

## OTORHINOLOGY

THOMAS C. GALLOW—*a.* Dry clinic. Asaerobic infections about the head. His special reference to osteomyelitis.

THOMAS C. GALLOW, JACOB LEIBOWITZ, and HAROLD E. D. VES—*a.* Dry clinic. Malignancies of head and neck

## CHILDREN'S MEMORIAL HOSPITAL

## Tuesday

## ORTHOPEDIC SURGERY

F. A. CHANDLER, FREDERICK S. SETTLER, C. V. PEARL, and M. A. PAGE—*s.* Operations. Shelf operation for congenital dislocation of the hip; extraperitoneal resection of the obturator foramen; stabilization of promontory, torticollis in the newborn; patellar advancement operations.

## Wednesday

## GENERAL SURGERY

ALBERT H. MONTGOMERY, J. IRELAND, WILLIS J. POTTS, J. J. MURPHY, and S. VERN—*s.* Operations and demonstrations

## Thursday

## ORTHOPEDIC SURGERY

KNOWLTON E. BURKE—*s.* Operations and demonstrations

## MICHAEL REESE HOSPITAL

## Monday

## GENERAL SURGERY

Staff—*s.* Symposium: Shock, transfusion, blood substitutes and allied problems.

## Tuesday

## GENERAL SURGERY

Staff—*s.* Operative clinic.  
Staff—*s.* Symposium: Gastrointestinal surgery.  
Staff—*s.* Symposium: Peripheral circulatory diseases and surgery of the diabetic patient.

## OBSTETRICS AND GYNECOLOGY

Staff—*s.* Operative clinic. Gynecological.

## DENTOCRANIAL SURGERY

Staff—*s.* Dry clinic.

## ORTHOPEDIC SURGERY

Staff—*s.* Operative clinic.

## Wednesday

## GENERAL SURGERY

Staff—*s.* Operative clinic.  
Staff—*s.* Symposium: Biliary tract diseases.  
Staff—*s.* Dry clinic: General surgical problems.

## OBSTETRICS AND GYNECOLOGY

Staff—*s.* Dry clinic: Obstetrical and gynecological.

## ORTHOPEDIC SURGERY

Staff—*s.* Dry clinic: Fractures, reconstructive surgery and allied problems.

## DENTOCRANIAL SURGERY

Staff—*s.* Operative clinic

## Thursday

## GENERAL SURGERY

Staff—*s.* Operative clinic.  
Staff—*s.* Symposium: Thyroid.  
Staff—*s.* Dry clinic: General surgical problems.

## OBSTETRICS AND GYNECOLOGY

Staff—*s.* Operative clinic

## DENTOCRANIAL SURGERY

Staff—*s.* Operative clinic

## ORTHOPEDIC SURGERY

Staff—*s.* Operative clinic

## THORACIC SURGERY

Staff—*s.* Operative and dry clinic: Progress in thoracic surgery

## NEUROSURGERY

Staff—*s.* Symposium: Cerebral traumas and other neurosurgical problems

## Friday

## GENERAL SURGERY

Staff—*s.* Operative clinic

# PRELIMINARY PROGRAM FOR 1942 CLINICAL CONGRESS

## RESEARCH AND EDUCATIONAL HOSPITALS

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### Monday

ERIC OLDBERG—2 GENERAL SURGERY  
Dry clinic

### Tuesday

GENERAL SURGERY  
GÉZA DE TAKATS and associates—9 Operative and dry clinic  
Splanchnic nerve section for hypertension Symposium on surgery of the autonomic nervous system  
Results of sympathectomy in Raynaud's disease and Buerger's disease, sympathectomy for megacolon, sympathectomy for retinitis pigmentosa, indications and technique for denervating the carotid sinus, results of splanchnic nerve section in hypertension, demonstration of renal biopsies and their correlation with clinical findings in hypertension

THORACIC SURGERY  
WILLARD VAN HAZEL and C IRENEUS—9 Operative and dry clinic

NEUROSURGERY  
PAUL C BUCY—2 Operative and dry clinic

OPHTHALMOLOGY  
HALLARD BEARD—9 "Garden variety" cye operations, illustrated in moving pictures

OTOLARYNGOLOGY  
PAUL H HOLINGER and A H ANDREWS, JR—9 Bronchosopic clinic  
F L LEDERER and staff—2 Operations

### Wednesday

GENERAL SURGERY  
WARREN H COLE and staff—9 Operative clinic Thyroid gland, peptic ulcer  
PAUL W GREELEY—9 Operations Plastic

OBSTETRICS AND GYNECOLOGY  
FREDERICK H FALLS, W H BROWNE, R A LIFVENDAHL, and A F LASH—2 Operative and dry clinic

ORTHOPEDIC SURGERY  
H B THOMAS and staff—2 Operative clinic Exploration of knee lumbosacral spinal fusion

GENITOURINARY SURGERY  
C M MCKENNA, J H KIEFER and R D HERROLD—9 Operative and dry clinic

NEUROSURGERY  
ERIC OLDBERG—9 Operative and dry clinic

OTOLARYNGOLOGY  
F L LEDERER—4 Otolaryngological seminar

### Thursday

GENERAL SURGERY  
CHARLES B PUESTOW and staff—9 Operations Biliary tract

ORTHOPEDIC SURGERY  
H B THOMAS and staff—2 Operative clinic Malunited fractures, operative correction of slipped femoral epiphyses

NEUROSURGERY  
W A GUSTAFSON—9 Operative and dry clinic

OTOLARYNGOLOGY  
F L LEDERER—2 Operative and dry clinic

### Friday

GENERAL SURGERY  
R B MALCOLM—9 Operative and dry clinic Surgery of the neck.  
PAUL W GREELEY—9 Follow up clinic on plastic surgery  
LOUIS W SCHULTZ—9 Operations Cleft lip and palate

OBSTETRICS AND GYNECOLOGY  
FREDERICK H FALLS, W H BROWNE, R A LIFVENDAHL and A F LASH—2 Operative and dry clinic

NEUROSURGERY  
PERCIVAL BAILEY—9 Operative and dry clinic

## ILLINOIS EYE AND EAR INFIRMARY

### Monday

OTOLARYNGOLOGY  
SAMUEL SALINGER—2 Dry clinic Cases involving plastic reconstruction of nose and face

### Tuesday

OPHTHALMOLOGY  
THOMAS D ALLEN—2 Operative clinic Glaucoma  
GLENDA W NETHERCUT and VERNON M LEECH—2 Operative clinic Cataract

OTOLARYNGOLOGY  
M A GLATT—2 Operative clinic  
EDWIN J BLONDER—2 Operative clinic Radical mastoidectomy  
ALFRED LEWY—2 Dry clinic

### Wednesday

OPHTHALMOLOGY  
PHILIP D O'CONNOR—2 Dry clinic Some problems of surgery of the eyelids, lantern demonstration

### Thursday

OPHTHALMOLOGY  
LOUIS G HOFFMAN—9 Dry clinic

OTOLARYNGOLOGY  
M A GLATT—2 Dry clinic End results of sinus surgery  
C H CHRISTOPHER—2 Operative and dry clinic Radical mastoid  
EDWIN J BLONDER—2 Dry clinic

### Friday

OPHTHALMOLOGY  
SAMUEL J MEYER—2 Operative clinic Cataract and glaucoma

## WESLEY MEMORIAL HOSPITAL

## Monday

## GENERAL SURGERY

WILLIAM A. HEDGECOCK—2. Cancer clinic.

## FRACTURES AND OTHER TRAUMAS

OSCAR H. HORRALL—2. Ununited fracture humerus, open reduction of calcus.

## Tuesday

## GENERAL SURGERY

GUY S. V. ALSTINE—1. Cholecystectomy  
W. M. McMillan— Operative clinic Gall-bladder disease.

HAYDEN E. BARNARD—2. Operative clinic Cholecystectomy appendectomy

SAMUEL J. FOSTER—1. Duodenal ulcer

## OBSTETRICS AND GYNECOLOGY

MARK T. GOLDSTEIN—9. Operative and dry clinic Gynecological.

## THORACIC SURGERY

JEROME R. HEAD—2. Thoracoplasty

## Wednesday

## GENERAL SURGERY

EARL O. LATIMER— Gastric resection.

## FRACTURES AND OTHER TRAUMAS

PHILIP H. KRECHMER and R. J. BRIDGEMAN—4. Open reduction of hip, Lorenz screw arthroplasty of hip, vital-lime cup recurrent dislocation of shoulder, Nicola operation.

R. T. McELVEIN—1. Dry clinic Certain factors in treatment and results in treatment of intracapsular and intertrochanteric femoral fractures, fib lantern slides

## ORTHOPEDIC SURGERY

PAUL B. MACINTOSH— Demonstration Plastics on the hip.

## Thursday

## GENERAL SURGERY

RAYMOND W. McNEAL—9. Gall-bladder and stomach cases.

EARL O. LATIMER—1. Inguinal hernia repair

NORMAN G. PARRY—2. Breast amputation

## ORTHOPEDIC SURGERY

HAMMAR KELLENBACH—2. Arthritic arthroplasty of knee

## GENITOURINARY SURGERY

DONALD K. HINES— Suprapubic prostatectomy

## OTOLARYNGOLOGY

JOSEPH E. SCHAEFER— Plastic of mandible cleft palate.

## Friday

## GENERAL SURGERY

PHILIP SHAMBAUGH—9. Operative clinic Gall-bladder appendectomy hernia repair

## OBSTETRICS AND GYNECOLOGY

ROCCO A. MASON—9. Dry clinic Cesarean operation.

## FRACTURES AND OTHER TRAUMAS

EDWARD L. COOPER—9. Management of compound fractures.

## GENITOURINARY SURGERY

VICTOR D. LEPTINAR—2. Urological clinic.

## GRANT HOSPITAL

## Tuesday

## GENERAL SURGERY

A. G. ZIMMERMAN—9. Operations.

M. H. STEINBERG—9. Intestinal anastomosis and rectal surgery

JOHN R. ORNDORFF and B. H. ORNDORFF—9. Operations General and tumor

## Wednesday

## GENERAL SURGERY

KARL A. MEYER—9. Operations.

## Thursday

## FRACTURES AND OTHER TRAUMAS

GEORGE L. APPELBACH—9. Open reduction of fractures

## GENITOURINARY SURGERY

WILLIAM H. GIBBS—9. Dry clinic.

EDWARD F. HEN—9. Dry clinic.

## OTOLARYNGOLOGY

GEORGE F. DENNIS—9. Operations.

## Friday

## OBSTETRICS AND GYNECOLOGY

FREDERICK H. FALLS—9. Operations Gynecological.

E. W. FERNBERG—9. Operations Gynecological.

## OPHTHALMOLOGY

OSCAR H. KRAFT—9. Operations.

B. T. HOFFMAN—9. Operations.

## OTOLARYNGOLOGY

CARROLL W. STUART—9. Operations

## LORETTO HOSPITAL

## Tuesday

## GENERAL SURGERY

L. F. PLEAK. Shock and hemorrhage.

A. E. STEWART. Abdominal surgery

T. J. ECKHARDT. Traumatic abdomen

E. P. VAUGHAN. Pelvic surgery

J. A. VALENTINE. Head injuries.

J. H. THOMAS. Injuries of extremities.

O. M. WALTER. Biliary surgery

## OBSTETRICS AND GYNECOLOGY

H. T. LITTLE. Operation. Vaginal hysterectomy

## GENITOURINARY SURGERY

C. C. SARKIS. Traumatic injury of genitourinary tract

## UROLOGY

F. M. SYLVESTER. Brain and spinal cord injuries.

# PRELIMINARY PROGRAM FOR 1942 CLINICAL CONGRESS

## ST LUKE'S HOSPITAL

### Monday

J S COULTER—1 GENERAL SURGERY  
practice, Physical and occupational therapy in

J D ELLIS—2 FRACTURES AND OTHER TRAUMAS  
spine Diagnosis of compression fractures of  
E W RYERSON—3 Shelf operations for dysplastic hip  
joints  
J D ELLIS and LAURENCE M MARSH—4 Complicated  
fractures, lower end of radius

J W MARRON—2 OPHTHALMOLOGY  
Operative and dry clinic.

### Tuesday

PAUL W GREELEY—9 GENERAL SURGERY  
Operations Plastic  
E L JENKINSON—1 of the esophagus  
Stellate impression of the lower end  
H E MOCK, SR., and associates—2 Infectious granulomas  
of the gastrointestinal tract  
SELIM W McARTHUR—3 Errors in gastric diagnosis  
H E JONES—4 Venous mesenteric thrombosis

OBSTETRICS AND GYNECOLOGY  
H O JONES and associates—8 Operations Gynecological

ERIC OLDBERG—1 NEUROSURGERY  
Operative clinic

EARL H MERZ—1 OPHTHALMOLOGY  
Operative and dry clinic

### Wednesday

HARRY CULVER and T P GRAUER—8 GENITOURINARY SURGERY  
procedures Genitourinary

JOHN J WALSH—1 OPHTHALMOLOGY  
Operative and dry clinic

PAUL H HOLINGER and A H. ANDREWS, JR.—8 OTOLARYNGOLOGY  
choscopic procedures Bron  
H. R. LYONS and WALTER H THEOBALD—2 Operative  
and dry clinic embolectomy, sympathetic block, studies

### Thursday

GÉZA DE TAKATS and associates—8 GENERAL SURGERY  
vein ligation, indication and technique, demonstration  
of patients, traumatic aneurysms, aneurysms of the  
aorta, wiring, paravertebral alcohol injections, para  
sternal decompression, Sudeck's atrophy, frequent and  
important cause of disability following trauma, diagnosis  
and treatment of sudden arterial and venous occlusions,  
embolectomy, thrombectomy, sympathetic block, studies  
on heparin  
PAUL W GREELEY—9 Operations Plastic

ERIC OLDBERG—2 NEUROSURGERY  
Operations

FRANK BRAWLEY and JAMES W CLARK—2 OPHTHALMOLOGY  
Eye clinic  
LOUIS BOTHMAN—3 Fundus diseases Kodachrome clinic

### Friday

Staff—9 GENERAL SURGERY  
Surgical rounds with weekly hospital clinics  
H. E. MOCK, SR., H. E. MOCK, JR., and WILFRED A MAJOR  
—10 Peripheral circulatory diseases of the extremities,  
refrigeration anesthesia in amputations  
W A CONROY and associates—1 Anesthesia procedures

RICHARD GAMBLE—1 OPHTHALMOLOGY  
Eye clinic

## MERCY HOSPITAL

### Tuesday

JOHN KEELEY, CHARLES F SAWYER, MICHAEL T Mc-  
GUIRE, HARRY A OBERHELMAN, and ARNELL K  
VAUGHN—9 GENERAL SURGERY  
Operative clinics Traumatic and general  
surgery

### Wednesday

HERBERT E SCHMITZ and associates—9 OBSTETRICS AND GYNECOLOGY  
Gynecological Operative clinic  
WILLIAM T CARLISLE and associates—9 Operative clinic  
Gynecological

### Thursday

CLEMENT L MARTIN—9 GENERAL SURGERY  
Operations Proctological

JOHN D CLARIDGE—9 ORTHOPEDIC SURGERY  
Operations

HERBERT E LANDES—9 GENITOURINARY SURGERY  
Operations

HAROLD C VORIS—9 NEUROSURGERY  
Operations

## HENROTIN HOSPITAL

### Days to be Announced

JOHN A GRAHAM GENERAL SURGERY  
O E VAN ALYEA Surgical clinic  
E L CORNELL Applied anatomy of nasal sinuses  
room Simplified wartime technique for delivery  
JOHN R. WOLFF Treatment of postpartum hemorrhage  
F LEE STONE Sterility  
A M BRAND Rôle of the male in abortions  
E L CORNELL. Bilateral fracture and dislocated shoulder  
in eclampsia

## PASSAIC ANT MEMORIAL HOSPITAL

## Monday

## ORTHOPEDIC SURGERY

EMIL D W HARTER—3 jo. Operations.

## Tuesday

## GENERAL SURGERY

J. R. BOENKHOFFER—9 Operations.  
 HARR M. RUCHTER—9 Operations.  
 JOHN A. WOLFE—9 Operations.

## OBSTETRICS AND GYNECOLOGY

ARTHUR H. CURTIS—9 Operations.

## ORTHOPEDIC SURGERY

P. CL. B. MACHURON—2 Operations.  
 JAMES K. SEACK—2 Operations.  
 EMIL D W HARTER—3 jo. Operations.

## GASTROENTERAL SURGERY

KNOWLTON E. BARKER—9 Operations.

## Wednesday

## GENERAL SURGERY

J. R. BOENKHOFFER—9 Operations.  
 SCHOKER L. KOCH—9 Operations.

## OBSTETRICS AND GYNECOLOGY

ARTHUR H. CURTIS—9 Operations.  
 GEORGE H. GARDNER—9 Operations.

## GASTROENTERAL SURGERY

KNOWLTON E. BARKER—9 Operations.

## NEUROLOGY

LOYAL D. W.—9 Operations.

## Thursday

## GENERAL SURGERY

J. R. BOENKHOFFER—9 Operations.  
 HARR M. RUCHTER—9 Operations.  
 JOHN A. WOLFE—9 Operations.

## ORTHOPEDIC SURGERY

EMIL D W HARTER—3 jo. Operations.

## Friday

## GENERAL SURGERY

J. R. BOENKHOFFER—9 Operations.  
 SCHOKER L. KOCH—9 Operations.

## OBSTETRICS AND GYNECOLOGY

ARTHUR H. CURTIS—9 Operations.  
 GEORGE H. GARDNER—9 Operations.

## NEUROLOGY

LOYAL D. W.—9 Operations.

## SWEDISH COVENANT HOSPITAL

## Wednesday

## GENERAL SURGERY

R. F. ELMER and W. N. STROMBERG—8 jo. Abdominal surgery.

## OBSTETRICS AND GYNECOLOGY

R. A. LAY, DANIEL G. F. HUBERT and HARRIS J. THUR—8 jo. Operations. Gynecological.

## FRACTURES AND OTHER TRAUMA

O. T. ROSENBERG—8 jo. Operative and dry clinic.

## OBSTETRIC SURGERY

JOHN T. GIBSON—8 jo. Operations.

## ILLINOIS MASONIC HOSPITAL

## Tuesday

## GENERAL SURGERY

STAFF—4. Operative clinic.

W. C. BOWENMASTER and L. KROHN—8. Partial gastrectomy.

C. OTIS KITCH—8. Cystotomy.

R. B. GAVIN—9. Cystostomy and pyelotomy.

J. F. D. VAN and A. E. WATKIN—9. Cholecystectomy.

WILLIAM E. KERRY and O. HARRIS—10. Colostomy for carcinoma of the cecum.

EDWARD W. WHITE—1. Nephrectomy.

T. G. WALLIN and BETULAN WALLIN—1. Radical mastectomy.

R. BRUCE MALCOLM and J. WALTER JOHNSON—1. Abdominal peritoneal resection.

PHILIP SAMMARITANO—12. Common duct stone.

## OBSTETRICS AND GYNECOLOGY

F. O. BOY—8. Operation Cesarean section.

H. W. MILLER and GLEN S. NELSON—9. Operation Hysterectomy.

W. E. PUGH and A. U. DYER—1. Operation Ovarian cyst.

## GASTROENTERAL SURGERY

WILLIAM H. GIBB and F. L. CROWTHER—1. Transverse colostomy.

C. C. SALMO—1. Prostatectomy.

## THORACIC SURGERY

MENG J. SANDER—2. Thoracotomy.

## NEUROLOGY

W. A. GUSTAFSON—1. Subtemporal decompression.

## Wednesday

## GENERAL SURGERY

ARTHUR H. GIBSON—1. Operation Tonsillectomy and adenoidectomy.

CHARLES J. DUTCH and H. E. OLIVER—1. Hemorrhoidectomy.

## OBSTETRICS AND GYNECOLOGY

DANIEL W. JEFFERSON—9. Perineorrhaphy.

## ORTHOPEDIC SURGERY

WALTER R. FRIEDER—10. Tenotomy.  
 CHARLES N. PRASE—1. Fixation of fracture of hip.

## OPHTHALMOLOGY

AL. SOWERS—9. Operation Cataract.

## OTOLARYNGOLOGY

H. E. T. VILCO—8. Subhyoid resection.  
 M. H. COTTELL and R. LOWERY—9. Radical mastoidectomy.

## ALBERT MERRITT BILLINGS HOSPITAL

*Tuesday*

## GENERAL SURGERY

WILLIAM E ADAMS, L R DRAGSTEDT, ALEXANDER BRUNDSCHWIG, and CHARLES B HUGGINS—9 Operative clinics

*Wednesday*

## GENERAL SURGERY

L R DRAGSTEDT, CHARLES B HUGGINS, DALLAS B PHFMISTER, and CLY H HATCHER—9 Operative clinics

*Thursday*

## GENERAL SURGERY

WILLIAM E ADAMS, ALEXANDER BRUNDSCHWIG, A. EARL WALKER, and HILGER P JENKINS—9 Operative clinics

*Friday*

## GENERAL SURGERY

DALLAS B PHFMISTER, L R DRAGSTEDT, ALEXANDER BRUNDSCHWIG, and CLY H HATCHER—9 Operative clinics

## JACKSON PARK HOSPITAL

*Tuesday*

## GENERAL SURGERY

A BAMBERGER—9 Operations  
C C CLARK—9 Operations Abdominal

## FRACTURES AND OTHER TRAUMAS

FRANK G MURPHY—9 Fracture cases

## GENITOURINARY SURGERY

S J SULLIVAN—9 Operations

*Wednesday*

## GENERAL SURGERY

H H COX—9 Operations  
W M SHERIN—9 Gall bladder operations  
A BAMBERGER—10 Head injuries

## GENITOURINARY SURGERY

WILLIAM YONKER—9 Operations

*Thursday*

## GENERAL SURGERY

NOAH FOX—8 Plastic surgery of the face  
DAVID S JAFFRAY—10 Operations  
A BAMBERGER—10 Abdominal injuries  
S J SULLIVAN, I G MURPHY, NOAH FOX, H H COX, and A BAMBERGER—12 Symposium Traumatic surgery

## OBSTETRICS AND GYNECOLOGY

L H STERN and CHARLES F GREENE—8 Operations

*Friday*

## GENERAL SURGERY

A BAMBERGER—9 Operation Thyroid  
C C CLARK—9 Operations  
H H COX—9 Operations

## NORWEGIAN-AMERICAN HOSPITAL

*Friday*

## GENERAL SURGERY

## Staff—9 Dry clinic

J M AMBERSON—9 Blood and plasma in surgery  
G B FAULEY—9 15 Peptic ulcer, modern concepts  
A M JENSEN—9 30 Sulfanilamide in general surgery  
J R ORNDORFF—9 45 Common duct surgery  
F H FOWLER—10 Perforative appendicitis  
J V FOWLER, JR—10 15 Thyroid gland surgery  
J E VERHAAG—10 30 Hernia from industrial causes  
H R FISHBACK—10 40 Tumor clinic, selected cases  
B A FINNE—10 45 Gall bladder surgery, nutritional aspects

WARREN JOHNSON—11 Carcinoma of the stomach

I M NICHOLSON—11 15 Scalp injuries

M E LICHTENSTEIN—11 30 Operating room decorum

J V FOWLER, SR.—11 45 Carcinoma of the breast

## OBSTETRICS AND GYNECOLOGY

## Staff—9 Dry clinic

B W BREISTER—9 Toxemias of pregnancy

P F SNYDER—9 20 Uterine tumors, differential diagnosis

I C UDESKY—9 40 Indications for use of forceps

## GENITOURINARY SURGERY

D F RUDNICK—10 Transurethral resection of the prostate

## FRACTURES AND OTHER TRAUMAS

M M CORBETT—10 20 Immediate treatment for fracture of the long bones

## OTOLARYNGOLOGY

M A GLATT—11 20 Tonsillectomy, control of hemorrhage

J W HARNED—11 40 Mastoid infection, danger signals

## WOMEN AND CHILDREN'S HOSPITAL

*Tuesday*

## GENERAL SURGERY

MARY E WILLIAMS—9 Operations

EMELIA J GIRYOTAS—10 30 Operations

## OBSTETRICS AND GYNECOLOGY

ELOISE PARSONS—2 Operations Gynecological

*Wednesday*

## GENERAL SURGERY

PEARL M STETLER—9 Operations

*Thursday*

## OBSTETRICS AND GYNECOLOGY

BERTHA VAN HOUSEN—9 Operations Obstetrical

BERTHA VAN HOUSEN—10 Moving pictures showing technique of pubiotomy and demonstration of patients

MAUDE H WINNETT—10 30 Operations Gynecological

BEATRICE E TUCKER—2 Operations Obstetrical

*Friday*

## GENERAL SURGERY

KATHERINE K TRUE—9 Operations

## SCIENTIFIC EXHIBIT

Demonstration of emergency medical field unit.



## PRESBYTERIAN HOSPITAL

## Tuesday

## GENERAL SURGERY

VIRGON C. DAVIS CARL B. DAVIS, KELLOGG SPEED,  
ALBERT H. MONTGOMERY and HILLIER L. BAKER—  
Operations.

## GENITO-URINARY SURGERY

HOLMAN L. KASTENBERG and associates—  
Operations.

## Wednesday

## GENERAL SURGERY

VIRGON C. DAVIS, CARL B. DAVIS, KELLOGG SPEED,  
ALBERT H. MONTGOMERY and HILLIER L. BAKER—  
Operations.

## OBSTETRICS AND GYNECOLOGY

A. E. KANTER—  
N. SPROUT HEARNY—  
EDWARD C. ALLEN—  
FRED O. PRIEST—

## Thursday

## GENERAL SURGERY

VIRGON C. DAVIS, CARL B. DAVIS, KELLOGG SPEED,  
ALBERT H. MONTGOMERY and HILLIER L. BAKER—  
Operations.

## OBSTETRICS AND GYNECOLOGY

A. E. KANTER—  
N. SPROUT HEARNY—  
EDWARD C. ALLEN—  
FRED O. PRIEST—

## Friday

## OBSTETRICS AND GYNECOLOGY

A. E. KANTER—  
N. SPROUT HEARNY—  
EDWARD C. ALLEN—  
FRED O. PRIEST—

## CHICAGO MEMORIAL HOSPITAL

## Monday

## GENERAL SURGERY

Staff—  
Panel discussion: Hospital care of civilian defense casualties.

## Tuesday

## GENERAL SURGERY

Staff—  
Staff—  
Staff—

## Wednesday

## GENERAL SURGERY

Staff—  
Staff—

## Thursday

## GENERAL SURGERY

Staff—

MUNICIPAL TUBERCULOSIS  
SANTARJUM

## Tuesday

## GENERAL SURGERY

CLEMENT L. MARTIN—  
OTOLARYNGOLOGY

## ORTHOPEDIC SURGERY

J. R. NORCROSS—  
OTOLARYNGOLOGY

## OTOLARYNGOLOGY

GEORGE HOLMES—  
Wednesday

## FEDERAL SURGERY

LEO L. HARDY—  
Thursday

## THORACIC SURGERY

RICHARD M. DAVIDSON—  
OTOLARYNGOLOGY

## OTOLARYNGOLOGY

S. H. SCHWARTZ—  
Friday

## Friday

## GENITO-URINARY SURGERY

D. F. RUDOLPH—  
ST JOSEPH HOSPITAL

## Monday

## GENERAL SURGERY

WILLIAM E. AYOUB—  
Tuesday

## Tuesday

## GENERAL SURGERY

HOMER McKENNA—  
Wednesday

## Wednesday

## GENERAL SURGERY

FRANKLIN B. MCCARTY—  
J. A. WINTERLY—  
Thursday

## GENITO-URINARY SURGERY

CHARLES M. McKENNA—  
Friday

## Thursday

## GENERAL SURGERY

B. J. FITZGERALD—  
OBSTETRICS AND GYNECOLOGY

## OBSTETRICS AND GYNECOLOGY

CLYDE J. GIBSON—  
Friday

## Friday

## GENERAL SURGERY

LEONARD A. KRATZ—  
WILLIAM C. BECK—

## MT SINAI HOSPITAL

*Tuesday*

## GENERAL SURGERY

V L SCHRAGER—9 Surgery of the stomach

## ORTHOPEDIC SURGERY

CHARLES M JACOBS—2 Operations

## GENITOURINARY SURGERY

HARRY C ROLNICK—9 Operations Genitourinary

## OTOLARYNGOLOGY

M R GUTTMAN—9 Nasal plastics

*Wednesday*

## GENERAL SURGERY

JACOB LIFSCHUTZ—9 Endoscopic clinic

J M MORA—9 Thyroidectomy

## OBSTETRICS AND GYNECOLOGY

A L KANTER—9 Operations Gynecological

*Thursday*

## GENERAL SURGERY

D A WILLIS—9 New operation for inguinal hernia

## OBSTETRICS AND GYNECOLOGY

A F LASH—9 Operation Vaginal hysterectomy

## OTOLARYNGOLOGY

S M MORWITZ—9 Operations

*Friday*

## GENERAL SURGERY

A. A. STRAUSS and S F STRAUSS—9 Operations Stomach and colon

## OTOLARYNGOLOGY

EMIL AISON—9 Operations

## ST MARY OF NAZARETH HOSPITAL

*Tuesday*

## OBSTETRICS AND GYNECOLOGY

M E UZNANSKI—10 Operations

A S SAMPOLINSKI—11 Operation Vaginal hysterectomy

*Wednesday*

## OTOLARYNGOLOGY

F J PISZKIEWICZ—9 Operations

*Thursday*

## GENERAL SURGERY

T M LARKOWSKI—9 Operative clinic

E H. WARSZEWSKI—10 Operative clinic

G M MUELLER—11 Operative clinic

*Friday*

## ORTHOPEDIC SURGERY

L M CZAJA—9 Operations

## VETERANS ADMINISTRATION FACILITY

*Tuesday*

## GENERAL SURGERY

B F WARD, P F BROWN, and H R FELDOTT—9 Operative clinic

R B MORELAND and R A. THOMAS—9 Operations Colon and rectal

## THORACIC SURGERY

JEROME R HEAD and T R HUDSON—9 Operative clinic

*Wednesday*

## GENERAL SURGERY

B F WARD, H R. FELDOTT, and H U STEPHENSON, JR —9 Operative clinic

MAX CUTLER, G R. ALLABEN, and R B MORELAND—9 Tumor clinic Presentation of cases, irradiation therapy

## ORTHOPEDIC SURGERY

W P SHERLOCK—9 Operations

## GENITOURINARY SURGERY

T G McDougall—9 Operations

*Thursday*

## GENERAL SURGERY

B F WARD, H R. FELDOTT, and H U STEPHENSON, JR —9 Operative clinic

R B MORELAND and R A THOMAS—9 Operations Tumor

## THORACIC SURGERY

JEROME R HEAD and T R. HUDSON—9 Operations

*Friday*

## GENERAL SURGERY

P F BROWN, B F WARD, and H R FELDOTT—9 Operative clinic

R B MORELAND and R A THOMAS—9 Operations Tumor

G R ALLABEN and R B MORELAND—2 Tumor clinic Diagnostic and treatment indications

## GENITOURINARY SURGERY

T G McDougall—9 Operations

## EVANGELICAL HOSPITAL

*Tuesday*

## GENERAL SURGERY

JAMES PATEJDL—9 Operative and dry clinic

*Wednesday*

## GENERAL SURGERY

G E JOHNSON—9 Operative and dry clinic

*Thursday*

## GENERAL SURGERY

PERCY E HOPKINS—9 Operative and dry clinic.

G HENRY MUNDT—9 Ménière's syndrome

## RAVENSWOOD HOSPITAL

Tuesday

## GENERAL SURGERY

Staff—8. Operations, demonstrations of amputations.  
Staff—10. Round table discussion by members of the  
Tumor Clinic.

Wednesday

## OBSTETRICS AND GYNECOLOGY

ARTHUR J. CHALOUPEK—8. Operation Gynecological.  
EDWARD F. FOX and ALBERT MCKEON—8. Operation  
Gynecological.  
Staff— Dry clinic: Obstetrical and gynecological.

## ORTHOPEDIC SURGERY

DARWIN B. FORD and associates— 9. Dry Clinic: Demon-  
stration of cases.

Thursday

## GENERAL SURGERY

JONAS J. MOORE—8. Pathological conference.

## GENITOURINARY SURGERY

NORMAN J. HICKEY—10. Operations.

## OPHTHALMOLOGY

Staff—2. Round table discussion.  
ALFRED N. MURRAY. Eye injuries.  
CHRISTIE H. LOCKWOOD. Strabismus; refraction.

## OTOLARYNGOLOGY

Staff—2. Round table discussion.  
WILLIAM J. MOONAN. Mastoiditis.  
JOHN C. VERMILION. Bronchoscopy.

## ST ANNE'S HOSPITAL

Tuesday

## GENERAL SURGERY

J. J. GRANT, E. P. GRAMES, J. W. KEAY, J. L. KRAFF,  
ADOLPH KRAFT, H. M. PETERSON, G. F. THOMPSON and  
N. T. FRASCON—9. Operations and dry clinic.  
R. M. CANNON and L. R. HALL—9. Dry clinic: Radiology  
and pathology.

## OBSTETRICS AND GYNECOLOGY

J. L. FLEMING and R. J. H. WILKS—9. Operat. and dry  
clinic.

## FRACTURES AND OTHER TRAUMAS

J. J. CALLAHAN and T. E. M. AUST—9. Dry clinic.

## OPHTHALMOLOGY

J. W. HAYDEN—9. Operative and dry clinic.

## GENITOURINARY SURGERY

H. J. DOOLEY and C. C. SELLING—9. Operations.

## OTOLARYNGOLOGY

J. W. H. IDEY—9. Operative and dry clinic.

## COLUMBUS HOSPITAL

Days to be Announced

## GENERAL SURGERY

J. L. FITZACK. Wounds and injuries of the stomach.

H. L. DOVIER. Deformities of the tarsus.

NATHAN FLAIDMAN. Surgical vs. medical treatment of a  
renal hypertension.

H. R. KIRBY. Incisions.

DANIEL A. OWEN. Experimental thyrotoxicosis.

EMERIT NORA and F. G. PETERSON. Three cases of Caisley's  
syndrome in one family with report on its etiology.

## THORACIC SURGERY

MICHAEL JOACHIMIDES. Collapse therapy of pulmonary tuber-  
culosis.

## EVANSTON HOSPITAL

Wednesday

## GENERAL SURGERY

FREDERICK CHRISTOPHER, M. H. HOWART and E. C.  
TYLER—9. Operations.

## FRACTURES AND OTHER TRAUMAS

DWIGHT F. CLAR—9. Fracture clinic.

## ORTHOPEDIC SURGERY

R. C. LOVERMAN—9. Operations.

## GENITOURINARY SURGERY

JAMES I. FARRELL—9. Operations.

## THORACIC SURGERY

JEROME R. HILL—9. Operations.

## OTOLARYNGOLOGY

THOMAS C. GALLOW. GREEN J. GREENWOOD, and  
H. C. BALLINGER—9. Nose and throat operations.

## OPHTHALMOLOGY

GAIL R. ZEPER—9. Eye operations.

## ST BERNARD'S HOSPITAL

Wednesday

## GENERAL SURGERY

J. C. WALL—8. Demonstration. Practical laceration  
exercises.

WILLIAM J. MURBOLLAND—9. Operations. Gall bladder.

J. B. HARRINGTON—9. Operations.

L. B. DONNELLY—9. Hemorrhoids, transverse.

M. E. CROUGHTON—10. Operations: Pelvic.

DR. CONNOR and R. J. MAHER—10. Clinical radiation  
therapy case demonstrations.

SAMUEL L. GONZALEZ— Injuries to lower extremity  
case demonstrations.

WILLIAM P. GUTH— Operations.

## OBSTETRICS GYNECOLOGY

DR. JACOB—8. Operations: Uterus.

DR. ROCK—9. Cesarean section.

## FRACTURES AND OTHER TRAUMAS

WILLIAM G. EMERY— Fractures of radius.

## OPHTHALMOLOGY

CLIFFORD P. SULLIVAN— Eye injuries, case demon-  
strations.

PRELIMINARY PROGRAM FOR 1942 CLINICAL CONGRESS  
CHICAGO LYING-IN HOSPITAL

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*Monday*

OBSTETRICS AND GYNECOLOGY  
Staff—2 Dry clinic

*Tuesday*

OBSTETRICS AND GYNECOLOGY  
Staff—9 Operative clinic  
Staff—2 Dry clinic

*Wednesday*

OBSTETRICS AND GYNECOLOGY  
Staff—9 Operative clinic  
Staff—2 Dry clinic

*Thursday*

OBSTETRICS AND GYNECOLOGY  
Staff—9 Operative clinic  
Staff—2 Dry clinic

*Friday*

OBSTETRICS AND GYNECOLOGY  
Staff—9 Operative clinic  
Staff—2 Dry clinic

AUGUSTANA HOSPITAL

*Tuesday*

GENERAL SURGERY  
NELSON M PERCY and OSCAR E NADEAU—9 Surgical  
clinic

*Wednesday*

GENERAL SURGERY  
A T LUNDGREN, EARL GARSIDE, JOHN W NUZUM, and  
RUDOLPH J ODEN—9 Surgical clinic

*Thursday*

GENERAL SURGERY  
NELSON M PERCY and OSCAR E NADEAU—9 Surgical  
clinic



# SURGERY

## GYNECOLOGY AND OBSTETRICS

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### THE ANAEROBIC NONHEMOLYTIC STREPTOCOCCI IN SURGICAL INFECTIONS ON A GENERAL SURGICAL SERVICE

WILLIAM ROBERTS SANDUSKY, M D, EDWIN J PULASKI, M D,  
BALBINA A JOHNSON, A B, and FRANK L MELENEY, M D, F A C S, New York, New York

IMPROVEMENTS in anaerobic bacteriological technique and the emphasis in recent years on the employment of anaerobic as well as aerobic cultures in diagnostic work have increased the number of isolations of anaerobic micro-organisms and as a result the number of reports on studies of infections due to these organisms. The Clostridia have received the greatest attention and their biological, immunological, and cultural characteristics are well known. Less attention has been paid to the anaerobic Gram negative bacilli and the anaerobic cocci. The latter group of organisms, while extensively reported in European literature (73), have received considerably less attention in the American literature and, save for their rôle in puerperal infections, knowledge concerning them is not widely disseminated.

This paper will be concerned only with the anaerobic nonhemolytic streptococci, and its purpose is to review critically the literature regarding this group of organisms and to present 170 cases of surgical lesions from which

the anaerobic nonhemolytic streptococci were recovered.

#### REVIEW OF THE LITERATURE

The first isolation of an anaerobic nonhemolytic streptococcus is generally credited to Veillon, who in 1893 described under the name of *Micrococcus foetidus* a strictly anaerobic coccus growing in short chains and producing gas and a fetid odor in cultures. This organism had been isolated in pure culture from a case of suppurative Bartholin's glanditis, and in association with other organisms from a case of Ludwig's angina and a perinephritic abscess.

Since Veillon's report there have appeared in the literature numerous articles, some reporting series of cases, others dealing with isolated observations, on the recovery of anaerobic nonhemolytic streptococci, in pure culture and in association with other organisms, from various lesions as well as healthy body cavities and surfaces. A list of these sources, tabulated on the basis of the normal habitat of the organism in the human body is presented in Table I. This same grouping has been adhered to in the review of the literature which follows.

From the Bacteriological Research Laboratory of the Department of Surgery, College of Physicians and Surgeons, Columbia University, and the Surgical Service of the Presbyterian Hospital.

TABLE I.—THE NORMAL HABITAT SOURCES OF INFECTION AND DISEASES FROM WHICH THE ANAEROBIC NONHEMOLYTIC STREPTOCOCCI HAVE BEEN RECOVERED

*Oral cavity—*

Normal flora Normal abscesses. Gingivitis Ulcerative stomatitis Dental caries Tooth granulomas Alveolar abscesses Retropharyngeal abscesses. Tonsillitis Deep cervical abscesses Ludwig's angina. Infected carcinoma Scomitis Mastoiditis Otitis media Leptomeningitis Cerebral abscess Aspiration pneumonia Pulmonary gangrene Lung abscess. Empyema thoracis. Septicemia Tooth abscess

*Gastrointestinal tract—*

Normal intestinal flora Acute and chronic cholecystitis Liver abscesses Acute appendicitis Appendiceal abscesses Acute peritonitis Peridiverticulitis. Nosocomial infections Wound infections

*Female genitourinary tract—*

Normal flora Foul lochia Endometritis Parametritis Cervicitis Bartholinitis. Salpingitis. Tubo-ovarian abscesses Peritonitis Infected carcinoma Septicemia Metastatic abscesses Thrombophlebitis Septic abortion Bacterial endocarditis Pulmonary gangrene

*Miscellaneous*

Accidental wounds War wounds Gas gangrene Post-operative wound infections Intertrigo Perianthral suppurations Pyoderma. Perinephritic abscesses Osteomyelitis Synergistic gangrene

*The oral cavity* The bacteria present in the mouth are subjected to great variation both in number and in kind. The amount of detritus, the presence of mucus and organic matter all favor the growth of bacteria and the production of inflammatory conditions of the gums, tonsils and pharynx. Of the great number of different organisms which abound in the mouth and saliva, among the commonest are the Gram positive cocci, including the anaerobic nonhemolytic streptococcus. Lewinowicz (1901) isolated from the mouths of sucklings an extremely minute streptococcus growing only under strictly anaerobic conditions and producing neither gas nor odor in artificial media. Since this report other observers have confirmed the almost constant presence of anaerobic nonhemolytic streptococci in the human mouth as part of its normal flora. The percentage of positive cultures, low in infants, increases with the appearance of teeth (5). These organisms have been cultured from pyorrheal gums (25 47 63) from the lesions of ulcerative stomatitis (43) from tooth sockets (53) after extraction and from alveolar abscesses (3 67). Such foci may become a source of severe infection elsewhere. A badly abscessed tooth may occasion a deep cervical

abscess or a Ludwig's angina. Carcinomas connected with the oral cavity sometimes become infected with these organisms. Recently Freeman has reported 13 positive cultures which were obtained in 18 cases. Anaerobic nonhemolytic streptococci have been isolated also from normal (67) and diseased paranasal sinuses (39).

Brisotto and Schottmoeller (59) called attention to the presence of these organisms in the foul smelling pus of chronic otitis media. The mastoid process may become affected, and mastoiditis and lateral sinus thrombosis with positive blood cultures have been reported. Brisotto pointed out that infection with these organisms may invade the cranial cavity with the development of localized abscesses or diffuse purulent leptomeningitis. He believed the anaerobic streptococci in these instances to be of buccal origin. Meloney (45) has also reported chronic brain abscesses due to anaerobic nonhemolytic streptococci. Meningitis due to these organisms has been observed by other authors (39) as has cerebral abscess (26) of hematogenous origin.

Frankel, Kinsling (35) Reye and Weirich have made significant contributions to our knowledge of septicemias secondary to infected tonsils. Instances of anaerobic nonhemolytic streptococci invading the blood stream following tonsillar and retropharyngeal abscess and tonsillectomy have been assembled. It has been shown that the organisms invade thrombosed veins, setting up a thrombophlebitis. The dislodged thrombi are transmitted to the brain, heart valves, or lungs. The outcome in a high proportion of the cases is fatal.

Human bites and lacerations produced when teeth are struck, frequently result in very serious infections especially when the hand is the injured member. The resulting infection is marked by an intense edema, a foul discharge and a gangrenous wound which may involve bones and joints. In a review of the bacteriology of human bite infection, Barnes and Blubby were able to collect only 10 papers which contained accounts of cultural studies and among them were only 6 which had anaerobic as well as aerobic cultures. In all of these anaerobic Gram positive cocci were uniformly

present, frequently in combination with spirochetes and fusiform bacilli. The most serious human bite infections, according to Jaeger, are due to anaerobic streptococci, and he states that the course of the infection is not controlled until the anaerobes are eradicated. Meleney (44) believes that all serious human bite infections are due to the synergistic action of anaerobic nonhemolytic streptococci with the fusiform bacilli and spirochetes, the combination of these organisms being much more virulent than pure cultures of the same organisms.

The bacteria commonly found in the oral cavity are capable of invading the lungs and producing varying degrees of tissue destruction and ultimately abscess formation. Guillemot in 1898 (27), first called attention to the presence of anaerobic nonhemolytic streptococci in putrid lung abscesses and other pleuropulmonary diseases. Since this account these organisms have been reported (13, 19, 25, 26, 28, 34, 39, 54, 55, 67, 75, 76), in connection with cases of pneumonitis, pulmonary gangrene, lung abscess, and empyema. Kissling (34) pointed out that the aspiration of these organisms with blood, mucus, or fragments of tissue in the course of tonsillectomy or extraction of teeth may give rise to lung abscess. Postpneumonic abscesses sometimes yield anaerobic streptococci. While not definitely proved, these are probably due to the invasion of the devitalized or infected areas of lung by micro-organisms from the mouth. Cultures of pulmonary abscesses present the most varied types of bacterial findings. Smith believes that the fuso-spirochetal group of anaerobic organisms are probably the etiological agents. Kissling (34), on the other hand, concludes from his studies that the cause of pulmonary abscess and gangrene is the anaerobic nonhemolytic streptococcus and that the spirochetes and fusiform bacilli which are frequently found in connection with this organism are saprophytes, having been carried into the lung substance in the process of aspiration, where they find an environment favorable to their existence and multiply in great numbers. Pilot and Davis state "it would seem that the streptococcus or other pyogens affect the [lung] tissue first, preparing

the soil for the growth of the anaerobes [fuso-spirochetal]." Thus far we have been concerned with the anaerobic nonhemolytic streptococcus in relation to pulmonary abscess of the spiration type. We shall later see that it plays a similar rôle in the embolic infections.

*The gastrointestinal tract.* Jacobsen in 1908 was probably the first to mention the isolation of anaerobic nonhemolytic streptococci from the normal intestinal tract. He reports finding them in the stools of newborn infants. In 1926, Tissier was able to isolate from cases of putrid enteritis anaerobic nonhemolytic streptococci which he described as a new species under the name *Coccus lanceolatus anaerobius*. While undoubtedly the anaerobic streptococci are normal inhabitants of the gastrointestinal tract, it is possible that some may be introduced from the mouth in the process of swallowing saliva. McDonald, Henthorne, and Thompson reported a perforated duodenal ulcer which was followed 2½ months after surgical closure by a subdiaphragmatic abscess, empyema thoracis, and multiple abscess of the liver. Anaerobic nonhemolytic streptococci were obtained in pure culture from the latter. Presumably the organisms originated in the spilled duodenal contents. Gilbert and Lippmann (23) recovered these organisms in 25 per cent of their cases of suppurative cholecystitis. There is an abundance of literature on the bacteriology of acute appendicitis, and numerous investigators (1, 2, 9, 30, 39, 46, 74) have shown that the anaerobic nonhemolytic streptococcus forms part of the bacterial flora of acute suppurative, gangrenous, and perforative appendicitis, with peritonitis or abscess. In this connection it is noteworthy that the commonly held belief that *Escherichia coli* is the cause of the foul odor of pus in appendiceal peritonitis has been refuted by several observers (2, 9, 30). Certain anaerobic organisms, among which are the anaerobic nonhemolytic streptococci, are responsible for this foul odor. Terrell reported an interesting case of infection on a superficial anal fistula which spread rapidly into the deep subcutaneous tissues of the skin over the trunk and extremities. From the areas of drainage established by numerous surgical incisions, anaerobic strep-



tococci and *Escherichia coli* were grown out consistently.

*The female genital tract* The relationship of the anaerobic nonhemolytic streptococcus to puerperal infections has been well presented in the articles of Schottmueller (59, 60) Schwarz and Dieckmann Harris and J H Brown Colebrook, T K. Brown and Watson. A résumé of the rôle of this organism in puerperal infections is repeated here for the sake of general interest.

Two years after Veillon's report, Kroenig and Menge (48) first independently and later in collaboration (49) described a strictly anaerobic streptococcus which had been isolated from the vagina in pregnancy and in puerperal infection as well as from cases of parametrial suppuration and peritonitis. In 1905 Natvig recovered from the vagina in pregnancy anaerobic streptococci which produced gas and foul odor in artificial media. He concluded that all strains of anaerobic streptococci, because of their similarity in producing gas and odor should be placed in a single group to which he gave the name *Streptococcus anaerobius*. He was apparently unaware of the strain isolated from the mouths of sucklings by Lewkowitz 4 years previously which produced neither gas nor odor in artificial media. There then followed reports by numerous observers dealing with the recovery of anaerobic nonhemolytic streptococci from the normal vagina and from various puerperal states and infections. Suggestions were made by some that these organisms were the cause of puerperal fever. It was not however until 1910 when Schottmueller (59) isolated from puerperal infections a strain called by him *Streptococcus putridus* that interest in the anaerobic streptococcus as a causative agent of these infections received real acceleration. This worker then and subsequently (60) has emphasized the definite relationship of the anaerobic nonhemolytic streptococcus to puerperal infections. He described a series of cases, chiefly following abortions characterized by foul lochia, high intermittent fever, chills, rapid pulse and locally thrombosis of the pelvic veins. He stated that once the organism (*Streptococcus putridus*) was able to invade the tissues it

became virulent. Detached thrombi were able to establish metastatic infections in other organs, particularly the lungs and pleura. His observations have since been confirmed and extended by other workers. Many phases of puerperal infection have been subjected to extensive investigation from which we have learned certain facts. These are as follows: nonhemolytic anaerobic streptococci exist in the normal vagina (10, 11, 64, 77) and under ordinary circumstances are nonpathogenic. Under certain conditions, however, they may acquire virulence and may cause mild infections characterized by profuse fetid lochia, low grade fever of short duration, and a soft, tender, subinvolved uterus. From such mild infections more serious ones may ensue. There may be extension to the peritoneal cavity with the production of peritonitis. There may be thrombophlebitis of the pelvic veins and a remitting fever lasting for considerable time. The organisms may invade the blood stream and produce a true septicemia. Infarcts arising from thrombophlebitis of the pelvic veins may establish metastatic infections in the lung leading to pulmonary gangrene or suppuration. Bacterial endocarditis has been observed. A certain number of these puerperal infections have gone on to fatal termination. Some observers (50, 71) have reported the detection of anaerobic streptococci with other anaerobes in infections superimposed upon carcinoma of the cervix and fundus of the uterus. In 25 cases of chronic tubo-ovarian abscess Altmeier (3) found the anaerobic streptococcus in pure or in mixed cultures by far the most frequent organism.

*Miscellaneous sources* There are numerous infections, other than those already mentioned, from which anaerobic nonhemolytic streptococci have been recovered. Greater knowledge concerning the mode of contamination in each instance would in all probability lead to an accurate determination of the original source for the organisms and a more adequate grouping.

Those infections apparently arising from the skin are an example. Almost any type of micro-organism may be found on the skin surface the number and varieties depending largely on the body location environmental

conditions, and opportunity for contamination from various sources. Sussmann, in a study of intertrigo, reports anaerobic nonhemolytic streptococci commonly present and, according to this author, responsible for the foul odor attending the disease. The skin is only one of the many sources for contamination of acute traumatic wounds, however, for the sake of convenience, observations on the bacteriology of such cases will be included in this section. Studying the bacterial flora of acute traumatic wounds, Pulaski, Melency, and Spaeth examined débrided tissue fragments which included skin, and they recovered anaerobic nonhemolytic streptococci from 13 cases, 65 per cent. Cottet (17) and Gerard and Romant have reported the detection of these organisms in war wounds at varying intervals after injury. Three cases of gas gangrene developing in traumatic wounds of civilian practice and war and apparently due to the anaerobic nonhemolytic streptococcus have been described in the literature (40, 62).

An unusual postoperative infection is the progressive bacterial synergistic gangrene recognized as a clinical entity by Melency (6, 42). This is an excruciatingly painful chronic gangrene of the skin occurring infrequently as a complication of gastrointestinal or thoracic operations and characterized by differentiation into three skin zones: outer brilliant red, middle dusky purple, and inner gangrenous with a central area of granulation tissue. Melency has demonstrated experimentally that the infection is due to the symbiotic action of a microaerophilic nonhemolytic streptococcus and a hemolytic *Staphylococcus aureus*. The streptococcus is not strictly anaerobic but is in that group called by Prévot "anaerobes by predilection."

As early as 1900 Cottet (16) in his thesis reported on the recovery of anaerobic streptococci from fetid periurethral suppurations, pyonephrosis, perinephritic abscesses, and other urinary infections. It is only recently, however, that infections of wounds following operations on the urinary tract have been mentioned in the literature. Mathé, reporting such a case, urges careful anaerobic bacteriological studies on all wounds of the urinary tract which resist the usual forms of treatment.

Anaerobic nonhemolytic streptococci in conjunction with other organisms have been grown from the fetid pus of osteomyelitis (38, 52).

#### CLASSIFICATION

Morphologically the anaerobic nonhemolytic streptococci are not strikingly unlike other varieties. They differ from the aerobic streptococci in their intolerance to oxygen. Gottlieb was able to demonstrate that the presence of oxygen in the media tends to act as a sterilizing agent for these organisms. Other observers (53, 67) have reported that certain strains remain strict anaerobes after as many as 50 to 100 generations.

In the field of classification, Prévot's work (55) is important in that it represents the first serious attempt to classify the anaerobic nonhemolytic streptococci and to group them according to their morphological and biological characteristics. In his original scheme he placed these organisms in 3 groups. In group A were those which produce gas and fetid odor in artificial media. This group includes *Streptococcus foetidus* (Veillon, 1893), *Streptococcus anaerobius* (Kroenig, 1895) and *Streptococcus putridus* (Schottmueller, 1910). Group B contained those which produce neither gas nor odor. Into this fall *Streptococcus micros* (Lewkowicz, 1901) and *Streptococcus intermedius* (Prévot, 1925). Group C contained only one organism, *Streptococcus evolutus* (Graef and Wittneben, 1907) which produces neither gas nor odor and which is an anaerobe by predilection (microaerophilic). Recently Prévot (56) has revised the general grouping, forming two groups instead of three. Group A, to the list given is added *Streptococcus lanceolatus* (Tissier, 1926) and Group B, which now includes *Streptococcus evolutus*. The organisms in each group are distinguished from each other by their biological reactions and morphology. The classification is still elaborate and the differentiation is not clear in many instances.

Dissatisfied with the then existing method of classification, and with the hope of arriving at a more adequate one, Colebrook and Hare (15) studied sixty strains of anaerobic streptococci isolated from the blood stream and uteri in cases of puerperal sepsis. They were able

to recognize four chief types based on morphology and colony appearance on horse blood agar. These were referred to as types A, B, C, and D. The former two occurred commonly; the latter two were seldom seen. This classification is open to criticism because of the emphasis and dependence placed on colony appearance as a means of differentiation.

Weiss and Mercado working with two strains of anaerobic nonhemolytic streptococci on the basis of protein extract studies found these organisms sufficiently different in their immunological properties to constitute distinct entities. This seems to represent a proper approach to the problem of classification but the number of strains studied should be larger to be considered significant.

Recently Stone has reported a study of the biochemical and immunological properties of 26 strains of nonhemolytic anaerobic streptococci isolated from the uterus of parturient and postabortal women. This worker could discern no correlation between any two biological methods of grouping. Nor was it possible to form definite groups from these strains by means of precipitin reactions. He did, however, conclude that certain antigens are present in common and that a study of such antigens may well aid in classifying the organism.

#### REPORT OF CASES

Bacteriological studies on the cases reported in this paper were made in the Bacteriological Research Laboratory of the Department of Surgery of the College of Physicians and Surgeons, Columbia University. Since July 1, 1939, this laboratory has received for diagnosis all bacteriological specimens from the surgical service of the Presbyterian Hospital and Vanderbilt Clinic. All of the specimens are studied for anaerobic as well as aerobic organisms. The material is inoculated in a 0.5 per cent dextrose cooked beef heart medium which has been previously boiled and rapidly cooled to expel the oxygen and is streaked on the surface of two 5 per cent sheep's blood agar plates. One of the plates is incubated under aerobic conditions. The other plate and the broth are incubated anaerobically for 18 hours in an atmosphere of hydrogen in a jar

a modification (45) of the McIntosh and Fildes apparatus being used. No cultures should be discarded until after one week and unless all morphological forms seen on the Gram stain preparation of the cooked beef heart medium have been recovered and identified, reincubation and replating of this medium is carried out. It has been our experience that those species which grow slowly can be cultivated better on an enriched<sup>1</sup> real heart infusion agar incubated under anaerobic conditions. Further details of the anaerobic technique used in this laboratory have been reported elsewhere (45). At this point it is well to state the criteria by which these nonhemolytic streptococci were judged to be anaerobes. We have included (1) those strains which remained strict anaerobes even after being subjected to repeated subcultures on artificial media (2) those strains which grew as strict anaerobes through the second generation but which because of a desire for economy in materials and time, were not further subcultured—it is possible that some of these in subsequent generations may have shown microaerophilic tendencies (3) those strains which were demonstrated to be preferential anaerobes and which would be classified according to Prévot as belonging to the *Streptococcus evolutus* group.

The services from which this material comes do not include otolaryngological, neurosurgical, urological, obstetrical, or gynecological patients. Of the 170 cases reported only 8 can be considered as belonging to these specialties. The number of cases in this series gains significance therefore when it is pointed out that the lesions in such a large proportion represent infections from a general surgical service and include both hospital and ambulatory patients. During the 27 month period, July 1, 1939 through September 30, 1941 the anaerobic nonhemolytic streptococcus has been isolated from 170 different lesions. It occurred 39 times in pure culture, 18 times in association with other anaerobes only, 96 times in association with aerobes only, and in 27 instances was present with both aerobes and other anaerobes.

<sup>1</sup>Enriched by the addition of 30% of sterile fluid, of 10 per cent cysteine hydrochloride, and 0.05% of yeast extract.

of blood,  
of 10 per

The 29 cases from which the anaerobic nonhemolytic streptococcus was isolated in pure culture are listed in Table II. These cases occupy a most important position in our series in that they present very strong evidence in behalf of the pathogenicity of the anaerobic nonhemolytic streptococcus. While it is not our purpose to enter into a detailed description or discussion of the clinical aspects of each of these cases, three groups of lesions and several individual cases are worthy of brief comment.

In numbers perirectal abscess heads the list, there were 9 of these from which this organism was obtained in pure culture. Clinically these were typically represented by an acute abscess situated in the perirectal region and accompanied by considerable pain and tenderness. They contained varying amounts of pus which was usually described as having a foul odor. Upon incision and drainage all save one healed promptly and there appeared to be, save in this instance, no tendency toward chronicity, except when concomitant anal fistulas were demonstrated.

In addition to this group of lesions there were 4 cases of infected pilonidal cyst and 3 of infected sebaceous cyst showing nonhemolytic anaerobic streptococci in pure culture.

The brain abscess case is quite similar to one which has been reported by Cohen (12). It followed pulmonary abscess with a secondary empyema, which was treated surgically at another hospital. This patient died subsequent to drainage of the brain abscess.

One of the cases of empyema is particularly interesting. This occurred in a 43 year old man who had been operated upon 6 years previously for acute appendicitis with perforation and as a sequela had developed chronic phlebitis in the left leg. Shortly before entry he was seized with sharp pleuritic pain. Examination revealed what was considered to be atelectasis and consolidation of the left lower lobe. He improved on sulfapyridine, however, subsequently there developed a localized collection of thick foul smelling green pus from which anaerobic nonhemolytic streptococci were obtained in pure culture on three different occasions. Recovery followed drainage by rib resection.

TABLE II — TWENTY-NINE CASES FROM WHICH THE ANAEROBIC NONHEMOLYTIC STREPTOCOCCUS WAS ISOLATED IN PURE CULTURE

	Cases
Perirectal abscess	9
Infected pilonidal cyst	4
Infected sebaceous cyst	3
Empyema thoracis	2
Cholecystitis	2
Abscess of thumb	1
Infected branchial cyst	1
Brain abscess	1
Appendiceal abscess	1
Intrapertoneal abscess	1
Liver abscess	1
Pericholecystic abscess	1
Lung abscess	1
Postoperative wound infection	1

The appendiceal abscess case occurred after an appendectomy had been performed nineteen days previously in another hospital. The wound had healed satisfactorily and the patient was ambulatory when the symptoms and signs of an intra-abdominal abscess presented. At operation this proved to be situated in the pelvis, was well walled off, and contained 100 cubic centimeters of thick yellow odorless pus from which anaerobic nonhemolytic streptococci were obtained in pure culture. Prompt recovery followed the operation.

Of the gall bladder cases one occurred in a 59 year old woman who at operation had a distended, acutely inflamed gall bladder filled with white bile and stones. Anaerobic nonhemolytic streptococci were obtained in pure culture from both bile and gall bladder wall.

A case of particular interest is that of a liver abscess, without demonstrable portal of entry which occurred in a 19 year old boy who experienced chills and fever for 4 weeks prior to entry. Uneventful recovery took place following a two stage transthoracic drainage of the abscess.

The lung abscess case occurred secondary to bronchogenic carcinoma, the intra-abdominal abscess case followed leiomyosarcoma of the uterus, and the case of pericholecystic abscess was a complication of acute cholecystitis with perforation of the gall bladder. The postoperative wound infection occurred in a thoracotomy wound following exploration for carcinoma of the esophagus. Among the 4 remaining cases there were no remarkable features other than the bacteriological findings.



Table III records the 170 cases by groups and indicates all of the organisms isolated in each group. Among these cases there can be found a wide range of lesions both in respect to their anatomical location and in degree of seriousness to the patient. In addition to the cases recorded in this table we have also recovered anaerobic nonhemolytic streptococci from cultures of the throat, sputum, vagina, urine, and feces. Because these do not represent instances of surgical infections they have not been included in this report.

An analysis of this material reveals that infections associated with the gastrointestinal tract are responsible for 84 or 49.41 per cent, of all cases. As would be expected *Escherichia coli* is the organism found most frequently in conjunction with the anaerobic nonhemolytic streptococcus in these lesions. In the group of 84 cases there are 28 instances of perirectal abscess. As has been pointed out previously from 9 of these cases streptococci were isolated in pure culture, and in 5 of the 19 remaining the only other organism present was an anaerobic Gram negative bacillus.

Seventeen pleropulmonary infections form another large group. Again as would be expected fusiform bacilli, spirochetes, and vibrios, usually diagnosed by smear, were the most frequently associated organisms.

Of a total of 13 cases of infected pilonidal cysts in which the anaerobic nonhemolytic streptococcus was present 4 yielded this organism in pure culture. In the 9 remaining cases the most frequently associated organism was the nonhemolytic *Staphylococcus aureus* which was present in 5 cases.

There were 7 infected sebaceous cysts. Three contained the anaerobic nonhemolytic streptococcus in pure culture, in one other it was present with *Staphylococcus albus* only, and in another the only associated organism was *Bacillus subtilis*.

A further analysis of the various organisms identified in conjunction with the anaerobic nonhemolytic streptococcus can be made from Table IV.

McDonald, Henthorne, and Thompson recovered anaerobic streptococci from the heart's blood of a fatal case with perirectal abscess, pelvic peritonitis, retroperitoneal and

TABLE IV—THE INCIDENCE OF THE ORGANISMS RECOVERED IN ASSOCIATION WITH THE ANAEROBIC NONHEMOLYTIC STREPTOCOCCUS—141 CASES

	Cases
<i>Anaerobic Bacteria</i>	
<i>Clostridium welchii</i>	16
<i>Spirochetes</i>	6
<i>Fusiform bacilli</i>	10
<i>Vibrios</i>	5
<i>Actinomyces</i>	3
<i>Bacteroides</i> group	4
Gram positive cocci, unclassified	1
Gram positive bacilli, unclassified	3
Gram negative bacilli, unclassified	15
<i>Microaerophilic bacteria</i>	
Hemolytic streptococcus	9
<i>Aerobic bacteria</i>	
<i>Streptococcus hemolyticus</i>	12
<i>Green streptococcus</i>	34
<i>Staphylococcus albus</i>	7
<i>Staphylococcus aureus</i> nonhemolytic	36
<i>Staphylococcus aureus</i> hemolyticus	29
<i>Micrococci</i>	2
<i>Bacillus subtilis</i>	7
<i>Diphtheroids</i>	8
<i>Escherichia coli</i>	46
<i>Bacillus proteus</i>	10
<i>Aerobacter aerogenes</i>	5
<i>Bacillus fecalis</i> alkaligenes	2
<i>Bacillus pyocyaneus</i>	8
Gram negative bacilli, unclassified	9

scrotal abscess, following a perforated carcinoma of the rectum.

Other than this, however, we have not been able to find reports in the literature dealing with the recovery of the nonhemolytic anaerobic streptococcus either alone or in association with other organisms from the pus of perirectal abscess, nor from infected pilonidal cysts or infected sebaceous cysts. These 3 groups of cases in our series are particularly noteworthy in this respect.

#### EVALUATION OF STUDY

It is apparent from the foregoing review and report of cases that the anaerobic nonhemolytic streptococci, in addition to being normal inhabitants of the oral cavity, gastrointestinal tract, female genitourinary tract, and skin surface, can be isolated from a wide variety of infectious processes in nearly all human tissues. The question is to whether or not anaerobic nonhemolytic streptococci are pathogens and if they are, whether they play etiological roles in the cases presented is a natural inquiry and a subject with which this

study has been concerned. This point has been raised repeatedly and as yet there is no satisfactory answer. That they are residents of certain organs in many instances as harmless saprophytes must be granted. Undoubtedly in certain instances the pathogenic rôle is assumed only when the tissues of the host have been subject to some alteration such as trauma, necrosis, diminished blood supply or chemical changes.

There is an abundance of evidence pointing to the fact that they are definitely pathogens for man either alone or in symbiosis with other bacteria. This is convincingly demonstrated in puerperal infections when in some instances it is possible to recover the organisms in pure culture from thrombosed pelvic veins, the blood stream, and distant metastatic abscesses. In our own group of cases, the chief basis for assuming that these streptococci are pathogens is the finding of them in pure culture in 29 (17.05 per cent) of the cases. This same point is made by McDonald, Henthorne and Thompson in reference to their series. These authors state that "the frequency with which they [anaerobic streptococci] were found in pure culture lends importance to these organisms as a cause of human inflammatory disease and suggest that they played a significant rôle in all cases in which they were present whether or not they were the sole pathogens present."

Animal experimentation might throw some light on the subject of pathogenicity. However in surveying this field we find that the various observers differ in the results which they have obtained relative to the pathogenicity of anaerobic nonhemolytic streptococci for laboratory animals. Lesions have been produced in animals by the use of pure cultures of organisms isolated from human cases. The streptococcus isolated by Veillon produced subcutaneous abscesses when injected into mice and guinea pigs. Marwedel and Wehrsig injected anaerobic streptococci from one of their cases of gas gangrene into a guinea pig and hemorrhagic gangrenous and gaseous edema and death ensued in 12 hours. Anaerobic streptococci were recovered from the diseased tissue. After repeated passages on artificial media this organism lost its viru-

lence and would no longer kill guinea pigs. Mendel was able to reproduce in rabbits lesions resembling pyorrhea by subcutaneous injections of pure cultures of *Streptococcus parvulus*. Numerous other instances illustrating the pathogenicity of the anaerobic streptococcus for laboratory animals are recorded. However the consensus among the writers is that, in general, laboratory animals are refractory to this organism. Our own experience with tests for animal pathogenicity has been limited. Experimentation along these lines should be carried out, particularly with those strains which are the only organisms isolated from a given lesion.

An adequate system for the classification of the anaerobic nonhemolytic streptococci is lacking. It is in this field that a golden opportunity for further work with these organisms is presented. Our experience with Pebov's classification has not been satisfactory. We have attempted to classify 37 of our strains, using as a basis the criteria suggested by him. In 23 instances classification was not possible because of the many incompatibilities with the biological reactions which are supposed to delineate the various type species. The 14 remaining strains were identified as follows: *Streptococcus intermedius*, 6; *Streptococcus micros*, 5; *Streptococcus anaerobius*, 1; *Streptococcus putridus*, 1; *Streptococcus evolutus*, 1. Each proposed classification has been based on studies of rather small numbers of strains and as far as the classification of the anaerobic nonhemolytic streptococci are concerned, we are sympathetic with the view of Dack who has stated that the anaerobic nonspore forming organisms, including the streptococci, have been assigned names and characteristics on the basis of inadequate study.

It is worth repeating that the cases recorded in this report together with the review of the literature serve to emphasize the fact that the anaerobic nonhemolytic streptococci can be isolated from a widespread variety of sources. The importance of this fact should not be minimized and a search for this organism should be made particularly in those surgical infections which cannot be explained on the basis of the organisms recovered from aerobic

cultures The value and importance of anaerobic, in addition to aerobic, studies by laboratories concerned with the bacteriological diagnosis of material from surgical infections is evident and can not be overemphasized

#### SUMMARY AND CONCLUSIONS

The literature dealing with the anaerobic nonhemolytic streptococcus, its habitat, cultural characteristics, and infections associated with it has been reviewed We have reported 170 cases of various types of surgical lesions occurring on a general surgical service from which this organism was isolated Twenty-nine of these cases showed anaerobic nonhemolytic streptococci in pure culture Recovery of this organism in pure culture, as well as in association with other organisms, from cases of perirectal abscess, infected pilonidal cysts, and infected sebaceous cysts is reported for the first time

There is as yet no adequate system for the classification of the anaerobic nonhemolytic streptococci

These organisms form a part of the normal flora of the human mouth, intestine, and female genital tract They are usually present in the rôle of harmless saprophytes, however, under certain conditions because of alterations either in the bacteria themselves or in the host, or because of symbiosis with other microorganisms present, they are capable of producing inflammatory processes in various body tissues and organs Among the infections in which this organism plays a part are certain ones of surgical significance Adequate bacteriological study of all surgical infections should therefore include a search for these organisms and other anaerobes as well as for those of aerobic variety, and this study emphasizes the importance of doing routine anaerobic cultures on all infections

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# THE EFFECT OF THERAPEUTIC DOSES OF X-RAY ON INFECTIONS AND INFLAMMATIONS

## Experimental Studies

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IN the fall of 1935, two of us (M and W) attempted to investigate the manner in which x-ray severt their effect on infectious processes, assuming the validity of the premise that the procedure had merit. Since the results were primarily of a negative nature and the work was unavoidably interrupted, the data were never published. However, in view of military interest in the use of x-ray in the prophylaxis and therapy of wound infection, especially gas gangrene, and since there is no known rational experimental basis to support this method of treatment in *Clostridium welchii* infection, we have undertaken a reinvestigation to see if we might possibly obtain experimental data to substantiate the growing clinical belief that irradiation is of value in treating human infections. It is the purpose of this paper to present data on the effect of x-rays on infections due to *Clostridium welchii*, on the organisms and their toxins, and on the toxins of *Staphylococcus aureus* and *Corynebacterium diphtheriae*. Part of the data was obtained in the fall and winter of 1935-1936 at the State University of Iowa, the remainder in the summer and fall of 1941 at the Indiana University Medical Center.

**Effect of x-rays on *Clostridium welchii* infection in guinea pigs** Guinea pigs of about 400 gram weight were injected intramuscularly in the thigh with a 24 hour culture of *Clostridium welchii*. The experiments in 1935 were performed with a culture recently isolated from a case of gas gangrene of the orbit at the General Hospital State University of Iowa. Preliminary determinations indicated that a 0.10 cubic centimeter dose of a 24 hour

chopped meat culture injected intramuscularly into the thigh would kill the animals regularly in 48 hours. This dosage was used to inoculate a series of 12 animals, 6 to be treated with x-ray at varying intervals and 6 to be used as controls. The infected area of each animal was treated 3 times with 100 roentgens, measured in air (1 millimeter aluminum, 140 kilovolts, 5 milliamperes), at 2½, 6½, 11½ hours after inoculation. The experimental and control animals died within 24 hours with no demonstrable effect of x-ray therapy.

We next tried the effect of x-rays on the viability of *Clostridium welchii in vitro*. A 24 hour brain broth culture was filtered to remove the tissue, leaving a uniform suspension of the organisms. The suspension was then divided into five 7 cubic centimeter portions and each was exposed to x-rays in an open Petri dish, respectively as follows: 500, 1000, 1500, and 2000 roentgens (0.3 millimeter aluminum, 133 kilovolts, 5 milliamperes), the fifth sample served as a control. Immediately after treatment the suspensions were plated out to make quantitative counts on the number of viable organisms remaining. No difference could be detected in the 5 samples tested, the number of organisms being the same in each.

We next attempted to determine if x-ray had any effect on the dermonecrotic toxin of *Clostridium welchii*. The Seitz filtrate of an 18 hour chopped meat culture of the organism was divided into two portions: one untreated, the other treated with 2000 roentgens of x-ray (0.3 millimeter aluminum, 133 kilovolts, 5 milliamperes). The samples were then treated on guinea pigs for dermonecrotic toxin, the treated filtrate being injected into the skin on the right side of the animal and the same volume of untreated toxin being injected on the left side. The size of the erythema and

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edema, as well as the elevation of swelling were carefully measured but no significant difference could be demonstrated between the reactions to the treated toxin and the control. The hemotordin (as oxidized lyalin) was also measured on the same sample of toxin, by using 1 cubic centimeter of 1 per cent washed sheep cells. Again, no real difference could be shown between the irradiated and the control lyalin. All experiments were duplicated to check the possibility of some technical error.

Having failed to demonstrate any real effect of x ray on infections produced by full grown cultures or on the toxins of *Clostridium welchii* we attempted to determine if x rays could be used to prevent the development of an inflammatory reaction to the toxic filtrate given intracutaneously. Guinea pigs of about 400 gram weight were divided into 2 lots, 1 group treated with 200 roentgens (0.3 millimeter aluminum, 130 kilovolts 5 milliamperes) 2 hours before inoculation the other group treated with the same dosage after inoculation. The reacting skin was measured as before but no difference could be detected between either group and the untreated controls.

In view of the growing interest in military circles, both in the United States and in England in the use of x ray as a prophylaxis in *Clostridium welchii* infection, and because of the continued reports of Kelly claiming value for the method in treating fully developed cases it was decided to recheck the use of x ray as a method of treating gas gangrene in the experimental animal. The work was started in August, 1941. We chose as our infecting organism the SR12 strain of *Clostridium welchii* (type A Willson's classification) obtained from the National Institute of Health. Preliminary titration showed that 0.10 cubic centimeter of a 24 hour culture was the smallest dose which could be relied upon to kill 50 per cent of guinea pigs weighing 400 grams when injected intramuscularly in the lateral aspect of the thigh. Doses of 0.12 cubic centimeter or more killed the animals in 12 to 20 hours and smaller doses (0.08 c.c.) killed only an occasional animal. We found that animals surviving 3 days without treatment invariably recovered spontaneously. A total of 40 ani-

mals inoculated with the standard dose was divided into 4 groups of 10 each to receive respectively 50 roentgens, measured in air (100 kilovolts, 8 milliamperes, no filter) twice daily 25 roentgens twice daily 100 roentgens daily and an untreated control group, the first treatment to start 6 hours after inoculation of the animals. Two animals in the group receiving 100 roentgens daily recovered from the infection all other animals including the controls died within 30 hours after inoculation. We therefore repeated the experiment using 135 guinea pigs divided into 3 groups of 45 each receiving varying amounts of culture, namely 0.15, 0.10, and 0.08 cubic centimeter. Graded doses of culture were used to allow for variation in growth and to be reasonably certain of having at least one group of animals surviving long enough to receive two doses of irradiation. Fifteen of each group were treated with 75 roentgens (100 kilovolts, 8 milliamperes no filter) twice a day 15 were treated with 100 roentgens once a day and the remaining 15 served as controls. X ray therapy was given 3 hours after inoculation. In each of these experiments animals receiving treatment twice daily received the second dose 8 hours following the first. The few which survived long enough to receive the scheduled second daily dose were treated 24 hours after the initial irradiation. Table I shows clearly the ineffectiveness of the treatment.

TABLE I.—EFFECT OF X RAY THERAPY ON *CLOSTRIDIUM WELCHII* INFECTION OF GUINEA PIGS. TREATMENT STARTED 3 HOURS AFTER INFECTION

Dose of infecting dose	Amount of ray therapy	No. of recoveries
	Untreated (control) twice daily	
0.1	75 twice daily	
0.1	100 once daily	
0.08	Untreated (control) twice daily	

*Effect of x-rays on toxin production.* In order to determine whether x-rays had any effect on toxin production young (3 hour) brain broth cultures of *Clostridium welchii* were treated

with 500 roentgens each (0.3 millimeter aluminum, 130 kilovolts, 5 milliamperes) at 3, 5, and 7 hours. The cultures were then centrifuged at high speed to remove the bacterial cells and thus to avoid the removal of the filter. The supernatant fluids were titrated for the dermonecrotic toxin by using guinea pigs as test animals. In three separate experiments no inhibition of toxin production could be demonstrated. Total counts made on the young, actively growing cultures showed no difference in the rates of growth between the control and treated cultures. Repeated tests with up to 5000 roentgens showed no inhibition of growth rates or production of toxin.

*Effect of x-ray on diphtheria toxin.* Stabilized diphtheria toxin was dispensed in 10 cubic centimeter quantities in Petri dishes and treated with 200, 500, 1,500, and 3,000 roentgens (0.3 millimeter aluminum, 133 kilovolts, 5 milliamperes). Varying dilutions of the toxin samples were made and tested intracutaneously in white rabbits to determine the minimal reacting dose in the skin. No definite effect was demonstrated (Table II).

TABLE II — EFFECT OF X-RAY ON STABILIZED DIPHTHERIA TOXIN

Volume toxin c.c.	Total volume injected c.c.	Erythema produced after treating toxin with the following doses of x ray					
		3000 r	1500 r	500 r	200 r	Un- treated	
0.00006	0.1	15 mm.	15 mm.	15 mm.	15 mm.	15 mm.	
0.00003	0.1	15 mm.	15 mm.	15 mm.	15 mm.	15 mm.	
0.000015	0.1	12 mm.	12 mm.	8 mm.	12 mm.	12 mm.	
0.0000075	0.1	10 mm.	10 mm.	10 mm.	10 mm.	6 mm.	

*Effect of x-ray on the toxins of Staphylococcus aureus.* Powdered *Staphylococcus aureus* toxin, received from the National Institute of Health was dissolved in saline and diluted for preliminary titrations to determine the minimal hemolytic dose for 1 per cent rabbit erythrocytes and the minimal dermonecrotic dose for guinea pigs. Ten cubic centimeter amounts of the toxin were treated with 200 and 1000 roentgens, respectively (0.3 millimeter aluminum, 133 kilovolts, 5 milliamperes), the control being left untreated. Titrations of hemolysis are shown in Table III.

TABLE III — EFFECT OF X-RAY ON THE HEMOLYSIS OF STAPHYLOCOCCUS AUREUS

Condition of toxin	Volume of toxin in c.c.					
	0.05	0.025	0.0125	0.00625	0.003125	0.0015625
Untreated	4+	4+	4+	2+	0	0
200 r	4+	4+	4+	2+	0	0
1000 r	4+	4+	4+	2+	0	0

Table IV shows effect on the dermonecrotic toxin.

TABLE IV — THE EFFECT OF X-RAY ON THE DERMONECROTIC TOXIN OF STAPHYLOCOCCUS AUREUS

Condition of toxin	Volume of toxin injected in total volume of 0.1 c.c.			
	0.001 c.c.	0.005 c.c.	0.0025 c.c.	0.00125 c.c.
Untreated	10 mm necrosis	4 mm necrosis	No reaction	No reaction
2000 r	10 mm necrosis	4 mm necrosis	No reaction	No reaction

## EVALUATION OF STUDY

Clinicians have long been impressed with the therapeutic effects of x-ray in infectious processes in humans. However, the literature is devoid of convincing experimental data, either as controlled human cases or animal inoculations substantiating this point of view. It is quite probable that many investigators have performed experiments attempting to obtain confirmatory information in the experimental animal. The absence of such evidence in the literature leads us to infer that they have failed in their efforts, but hesitated to make a negative report. It is realized that data obtained in animals may not be interpreted to apply directly to humans, especially due to *Clostridium welchii*. Guinea pigs inoculated with *Clostridium welchii* usually die within 48 hours or recover spontaneously. We have never been able to find a dosage of culture which would consistently kill the animals on the 4th, 5th, or 6th day. Those claiming benefit from x-ray in gas gangrene criticize the use of the guinea pig as the experimental animal because the condition is one of such rapid intoxication. On the other hand they claim dramatic results in certain cases of x-ray therapy in individuals moribund and even

comatose. Certainly these latter cases, would simulate the condition in guinea pigs infected with a minimal fatal dose and treated 3 hours after infection. In clinical work one could hardly hope to have a case earlier than this unless x-ray is used prophylactically in all wounds. Then one is not treating gas gangrene.

Another difference between practical x-ray therapy in humans with gas gangrene and guinea pigs infected with known pure cultures of *Clostridium welchii* is the etiology of the disease. Most clinicians consider as gas gangrene any condition of injury with local swelling and gas in the tissue as shown by palpation or roentgenograms. Thorough bacteriological examinations are not made in the majority of cases of so called gas gangrene. In those cases examined bacteriologically the customary procedure is to look for gram positive organisms morphologically similar to *Clostridium welchii*. It should be emphasized that this does not make a positive bacteriological diagnosis of *Clostridium welchii* infection even in the presence of gas in the tissue. It is sufficient to indicate a clinical diagnosis but not for a strict bacteriological diagnosis so one may compare the treated human case with experimental infections in which known organisms are used.

If one were to admit the value of x-ray in the treatment of *Clostridium welchii* gas gangrene in humans it would be of interest to know the mechanism by which this is brought about. Since the disease is primarily one of rapid intoxication one might suspect the effect would be on the toxin. This view is also suggested by certain reports claiming dramatic results in cases in which the patient is *in extremis*. We have been unable to demonstrate any deleterious effect of x-ray even in large doses, upon *Clostridium welchii* toxin *in vivo* or *in vitro*. At times we were inclined to believe the treated toxin was more active than the control but the differences were not marked. Certainly there was no evidence the dermonecrotic or hemolytic factors were reduced in the slightest. The effect of huge doses of x-ray was not tried since they were outside the realm of possible therapeutic application. It is interesting that treatment of the local area immediately after injection of

the toxin had no effect on the rate of development or degree of tissue reaction to the toxin.

The development of toxin by *Clostridium welchii in vitro* is known to take place in the rapidly growing phase of the growth curve. It is also known that in solution the toxin tends to disappear rapidly. One might consider therefore that possibly x-rays would retard the rate of formation of toxin and allow the body to develop active immunity or that it would accelerate the rate of deterioration of toxin. We were unable to show either effect.

#### SUMMARY AND CONCLUSIONS

1. In guinea pigs x-rays had no beneficial effect in the treatment of gas gangrene due to *Clostridium welchii*.
2. They were ineffective in reducing the number of viable vegetative forms of a 2 hour culture of *Clostridium welchii*.
3. They were ineffective in retarding the rate of growth of *Clostridium welchii*.
4. They did not prevent the development of hemolysin or dermonecrotic toxin of *Clostridium welchii*.
5. They would not prevent the development of dermonecrosis even if applied before or immediately after the injection of *Clostridium welchii* toxin.
6. They would not inactivate either the hemolysin or dermonecrotic toxin when applied *in vitro*.
7. They would not inactivate *in vitro* either the hemolysin or dermonecrotic toxin of *Staphylococcus aureus*.
8. They would not inactivate *in vitro* the toxin of *Corynebacterium diphtheriae*.

We are well aware of the fact that data obtained by treating *Clostridium welchii* infections in guinea pigs may not represent the results one would obtain by treating similar conditions in humans. It must not be forgotten however that the data presented in this report include not only experiments on infected animals, but also *in vitro* experiments on rates of growth, rates of toxin production, and attempts to destroy toxins *in vivo* and *in vitro*. In no experiment has any real effect been demonstrated with doses of x-ray even beyond that permitted for human therapy.

# PRIMARY CLEANSING, COMPRESSION, AND REST TREATMENT OF BURNS

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**T**HAT burns occur frequently and constitute one of the most serious problems in medical practice is accepted by all of us. The treatment of a burn has varied in many respects from time to time, and a review of the methods (4, 5, 8, 11, 12, 14, 16, 17, 19) cannot be discussed here. In the literature one is impressed by recent added knowledge in handling such cases through the efforts of the surgeons and those of the physiologists.

Burns constitute a degree of injury to the skin and underlying tissue which we recognize as being first, second, or third degree in extent. There is more to the picture than mere cutaneous destruction and the physiological phase must be emphasized. In any burn the vascular bed of the area has been seriously affected. Blalock (3, 7, 18) and other observers have definitely shown that in such an injury there is marked increased capillary permeability bringing about not only loss of blood plasma, of plasma proteins and electrolytes from the burned surface but also into the surrounding tissue. This loss, in turn, causes a diminished blood volume, decreased minute cardiac output, vasoconstriction, circulatory stagnation, tissue anoxia, and, in severe untreated cases, circulatory failure and collapse. If this picture is of sufficient magnitude so called "thermal shock" will follow immediately. It is not improbable that if it were possible to prevent the loss of blood plasma, of plasma proteins and electrolytes by any method whether by internal or external medications or by mechanical or chemical means, so called "thermal shock" not only could be alleviated but could practically be prevented.

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The injury produced by a burn is an open wound and is comparable to traumatic open wounds. Most burns are contaminated because they are exposed to the air, and to people hovering over them, allowing bacteria from the uncovered nose and throat to fall upon them. Not infrequently they are grossly infected by the application of home remedies. During the past 10 years the surgeons have proved that infected wounds, treated early, can heal primarily if properly cleansed and débrided. In brief, we advocate essentially this that a wound resulting from a burn can be converted from a potentially infected wound into a surgically clean one by the same surgical principles, enabling healing *per primam* or at least minimizing the infection. Prevention of infection is probably the most important single factor in the treatment of burns. Many observers, particularly Aldrich, have proved beyond question of doubt that so called "toxemia" and the clinical course is not only dependent upon the degree of infection, but also upon the type of organism found in the infected wound.

These relatively recent pathological concepts which have been set forth are responsible for the presentation of a method advocated by Koch, Mason, and Allen (2, 13, 15) and modified by us. It can rightfully be called "Primary Cleansing, Compression, and Rest Treatment of Burns." This procedure is outlined briefly in the following paragraph.

A burned patient is an emergency and must be seen immediately upon entry into the hospital. All nurses and doctors should wear caps and masks when handling such a patient. A rapid general examination will establish the presence of "thermal shock." Pain should be alleviated by the administration of morphine to adults and codeine to children. We believe that surgical cleansing and débridement can best be done only in the operating room and under general anesthesia. Ideally, the patient



Fig. 1 Washing of the wound with white soap and water for 10 minutes.



Fig. 2 Irrigation of soap from the wound by use of physiological saline solution.



Fig. 3 Removal of blisters and necrotic skin being carried out.

is placed on the table upon a sterile sheet and in position to facilitate best cleansing. General anesthesia is administered. The surgeons having been gowned and gloved in the usual fashion after scrubbing for 10 minutes drape the involved region with sterile towels and sheets. The wound is gently washed with white soap and water for 10 minutes (Fig. 1). The soap is irrigated from off the area, physiological saline solution being used (Fig. 2). Gross débridement is carried out during this procedure (Fig. 3). The surgical team changes gown and gloves after which the area is redraped. With the use of fresh instruments and containers a more minute débridement is now done and the wounds are gently washed a second time with white soap and water. Irrigation is carried out by means of physiological saline. The wound is covered with sterile fine mesh, single thickness vaseline gauze strips (Fig. 4) on top of which are placed flat gauze dressings followed with fluffed sponges. Pressure is exerted with a folded gauze roll (Fig. 5). Firm uniform compression is obtained not only upon the wound itself but also upon the surrounding tissue by applying large sterile sea sponges or sterile mechanic's cotton waste held with another folded gauze roll (Fig. 6). The dressing is made a complete surgical one by means of adhesive tape which maintains the pressure and aids immobilization of the involved part. In some instances light plaster casts have been applied. This dressing is allowed to remain untouched for from 8 to 4 days. In the case of first and second degree burns the wounds should be completely healed when the dressings are removed while in the case of

third degree burns, the wound usually allows the application of a split thickness graft as advocated by Blair and Brown. If there is mild infection of the granulating wound postage stamp Thiersch grafts may be safely applied. In the rare instances of gross infection the wounds must be prepared for grafting by suitable means.

In a series of more than 100 cases treated at the Cincinnati General Hospital and the Children's Hospital we have proved to our selves beyond the question of a doubt that one can convert a potentially infected burned wound into a surgically clean one.

We have good reasons to believe that surgical compression dressings will prevent so called thermal shock. It should be clear in the minds of all that since severely burned patients lose large amounts of blood plasma, hemoconcentration occurs. Concomitantly the loss of plasma proteins and electrolytes aids in mobilization of the blood plasma at the site of injury as is shown by the edema at that point. Therefore whole blood transfusion or administration of parenteral fluids is contraindicated since the former gives rise to further hemoconcentration and the latter increases local edema, which means loss of more plasma, plasma proteins and electrolytes. Blood plasma should be administered to control this abnormal physiology. Our clinical research reveals that surgical compression dressings aid materially in preventing this pathological physiological syndrome. Splinting of involved extremities in the position of function either by sterile aluminum splints or plaster casts aids greatly in wound healing and also in prevention of not infrequent serious contractures.

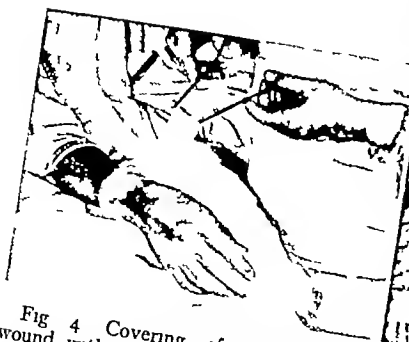


Fig 4 Covering of the cleansed wound with sterile fine mesh, single thickness vaseline gauze strips



Fig 5 Formation of a pressure dressing by use of a folded gauze roll



Fig 6 Uniform pressure being exerted on wound and surrounding tissue by "sterile mechanic's waste"

Plastic repair must not be minimized and wounds larger than a quarter in size should be grafted as soon as possible. The application of split thickness grafts or of small postage stamp Thiersch grafts is a matter of personal opinion. Skin replacement is the important feature.

As soon as the surgical compression dressing has been applied and the patient is in his bed, his general condition becomes the concern of those attending him.

Other than the clinical and laboratory observations made, there is little else to do except see that nursing care is adequate. Certainly the one great advantage this method has over other forms of treatment is the fact that no further local treatment is necessary. We have insisted on charting temperature, pulse, and respirations every half hour for the first four postanesthetic hours and every 4 hours thereafter. During the first 24 hour postoperative period the blood pressure should be observed frequently. It is important that the fluid intake and output of these patients be recorded in daily periods. A daily urine analysis should be reported until the patient is past the danger zone. It is important that the amount of fluid intake is within reasonable limits. Where one has facilities for capillary hematocrit (10), specific gravity and plasma protein determination (9), the control of fluid therapy should be much more accurate than by mere clinical impressions. Also, the indications for whole blood or blood plasma transfusion are shown by these observations. Using "Primary Cleansing, Compression, and

Rest Treatment" we have found, particularly in the case of children, as well as in adults, that these patients rapidly assume their own water balance by oral fluid intake and that parenteral administration is required only in the more severe cases. These patients are given high protein diets as soon as possible, and it has been our experience that solid food is fully enjoyed by the second or third day in most cases.

Morphine sedation should be used when pain is intense, however, as soon as possible codeine should be substituted. We believe that the use of codeine in the case of children is much safer than morphine.

In keeping with recent advances of vitamin therapy in wound healing and also in infection, we have given a vitamin B complex with ascorbic acid in capsule form. At this time we are unable to draw any conclusions as to whether or not this medication is beneficial in burned patients.

From a purely scientific standpoint it is desirable to have daily white and red blood cell counts, hemoglobin, plasma protein, blood chloride, nonprotein nitrogen or urea nitrogen determinations, and a carbon dioxide content of plasma. If one suspects liver damage in the case of severe burns, an icteric index and blood cholesterol should be obtained.

From a practical standpoint, such examinations would not only be expensive, but are not always available. Much can be learned from examination of a daily urine, red and white blood cell counts, a hemoglobin determination, and the clinical course of the patient.



Another advantage that this method has over other forms of treatment, particularly the tannic acid silver nitrate method is that after the initial dressing these patients are easily able to move or be moved in bed. This certainly inhibits the onset of upper respiratory tract infection and pneumonia which sometimes become serious complications. In the case of children we have been impressed by the fact that they not only frequently stand up in their cribs by the third or fourth day but that they play with their toys and seem to enjoy themselves. They have displayed more contentment with compression dressings than those cases treated otherwise. These facts have not only been observed by the attending doctors but also have vividly impressed the nurses in charge of them.

#### CONCLUSIONS

1. A method of treating burns has been advocated which will reverse the pathologic physiology presented by such cases.

2. This method advocated by Koch and Mason and modified by us we believe has definite advantages as compared with other methods of treatment.

Briefly enumerated these are (a) Infection is entirely prevented or minimized and this fact abolishes the toxemia and the febrile clinical course usually seen. (b) With sterile compression dressings it is believed that "thermal shock" and the complex blood concentration syndrome are prevented. (c) With the immobilized surgical compression dressing the involved area heals *per primam* in the case of first and second degree burns. In the case of third degree burns, the gran-

ulating tissues by virtue of their deadness allow for plastic repair much sooner than any other known method of treatment. In any case hospitalization is shortened. (d) There are certain definite advantages from a nursing standpoint in the use of this form of treatment. Some of these are: ease in handling the patient, general well-being of the patient, unrestrained activity which prevents complications such as pneumonia, a definite saving of dressings and hospital linen, and probably one of the most desirable features is the fact that children who are burned do not suffer psychotic changes which usually come from long periods of multiple daily moist dressings.

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# THE EXCLUSIVE USE OF SOAP AND WATER IN TRAUMATIC WOUNDS

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**I**N an endeavor to approach the results of Koch and Mason (7, 9) in the treatment of complicated compound wounds, we adopted their method 5 years ago for the manifold occasions presented by the accidents occurring in large industries. The method, while stressing meticulous primary wound cleansing with soap and water followed by excision of only devitalized tissue, does not predicate a sacrifice of, or lessening of emphasis on, any of the other particulars of treatment. Because of its simplicity and universal applicability, no attempt was made to alter any element of therapy, even though during this period the local use of sulfonamides, the newer detergents, and nonirritating metals have had a profound influence in determining some contemporary procedures.

Although it is apparent from a review of recent works that there are still many differences of opinion in regard to treatment, it is to be noted that during the past 5 years the use of the commoner antiseptics in a wound is more generally discouraged (1-7). It is chiefly with respect to the methods of débridement, chemotherapy, primary plating, and closure that the major differences exist, but it is also clear that the problem of the surgical cleansing of a wound is by no means agreed upon.

It is in relation to the latter aspect of therapy that the present study was made. It has been the experience of every surgeon to observe the occurrence of localized infection, tetanus, or septicemia following minor compound contusions, lacerations, and burns when the primary care has been of an accepted standard.

The increasing weight of evidence brought forth in comprehensive surveys of infection rates in excellent hospitals has made it apparent that there has been something quite inadequate even in the preparation of cases for elective surgery. Of all the factors having

to do with treatment of damaged and contaminated tissues, the one most likely to be variable and most subject to oversight is that of painstaking cleanliness of the wound itself. It is then of all times that patience and thoroughness are most vitally necessary. There does not exist after the first few hours another opportunity for the accomplishment of the cleansing which should be done at the earliest practicable moment.

This need not be an onerous duty or surgical drudgery. The time devoted to wound cleansing may also be given over to a more accurate appraisal of the anatomical and pathophysiological problems at hand, to a formulation of an orderly rather than a hastily planned mode of procedure, and may give the assistants and nurses a valuable opportunity to have available for the surgeon any unusual or additional instruments or materials necessary to meet the situation.

The time required for proper attention to soap and water application will necessarily depend chiefly upon the kind and degree of contamination and the size of the wound, but it is difficult to conceive of a workmanlike preparation of the intact skin in less than 10 minutes and a similar or much longer period for care of the depths of the wound. There is one certainty the more assiduous the primary cleansing the less likelihood will there be of infection and frequent subsequent dressings. The total time devoted to any individual case is much more likely to be greatly reduced and with infinitely greater safety. Also the time taken to cultivate patience, thoroughness, and judgment in one's surgical group, including internes and nurses, will be many times repaid.

As a matter of necessity, industrial nurses and surgical assistants will assume by far the major portion of the care of the lesser industrial wounds. In no instance however, is the care of the skin of a complicated wound, that

is, one involving exposed or injured tendons, nerves or bone delegated to orderlies or nurses. This work should be done by or under the direct supervision of the surgeon in charge.

Since the early days of antiseptic surgery the use of tincture of green soap has been advocated for the cleansing of surgical wounds of all nature. In the exhaustive bibliography which the subject of wound treatment entails, the washing of wounds has been overshadowed in importance by the emphasis placed upon antiseptic agents or some particular phase of treatment. From the time of Lister to World War I few stressed as urgently as Davison an exacting mechanical cleansing of the skin and the avoidance of the use of potential chemical irritants in the wound or on the surrounding surfaces. After the war the general acceptance of Dakin's solution as such, or in modified form and the newer germicidal solutions that appeared at short intervals did much to obscure the value of and delay the institution of rigid cleanly methods. The method we adopted has proved to be as nearly painless as any surgical treatment can be and the results have been such as to give us every encouragement to perfect ourselves in the details of this mode of treatment.

Alkaline soaps were formerly preferred because they more completely emulsified fat but prolonged and frequent use is quite irritating to the skin. In the first year of our present work, we used tincture of green soap and in the last 4 years we have used a neutral white soap solution. It is hardly necessary to add that a method which works so well for contaminated wounds may be applied as well to general surgery and most particularly to elective bone and plastic surgery for which aseptic technique must be of the highest order and in which iodine and other common skin antiseptics may be of positive harm. The danger of chemicals causing blistering of skin grafts has been called to our attention by the plastic surgeons. The latter group too has done much to show how without aid of chemicals the potentially dangerous regions of the nose and mouth could be made ready for delicate surgical operations by simple cleanly methods.

#### MANNER OF PREPARATION

The gentle treatment of tissues with a neutral white soap solution applied with sterile cotton balls or gauze constitutes the basic procedure. The wounds, no matter of what nature are first covered by sterile gauze or packed gently with it while the cleansing of the surrounding skin is in progress. On occasion benzene ether or prepared soaps which dissolve oils and greases more rapidly are used on the uninjured skin but the final clearing is given with white soap solution to secure a field of neutral reaction and to prevent the feeling of stiffness and dryness that remains after the above agents alone are used. While these substances are not altogether desirable they probably do little harm to intact skin and are frequently timesaving when the wounds are multiple and the patient is under anesthesia. When there are many wounds in a single individual to be cared for it is most desirable to have a separate team with a second nurse with her own table, cleansing materials, drapes and instruments.

When it is felt reasonably certain that the injured area will not be contaminated from the surrounding tissues, attention is given to the wound itself. With a wound of major significance the care of the intact skin is delegated to a gloved and gowned assistant, while the surgeon in charge is preparing himself for the care of the wound proper. After the draping is completed, the surgeon proceeds with the task of removing loose clots, foreign bodies and devitalized tissues with a set of instruments prepared especially for this purpose. Particulate material ground into bone surfaces is removed by patient scraping with curette, chisel or periosteotome. The wound is then cared for in thoroughgoing fashion with soap and water followed by irrigation with normal saline in abundant quantities, used preferably with a catheter so that every recess in the depths may be reached. Inasmuch as is possible it is during this time that a contaminated wound is made into a fresh, clean surgical wound.

Reid and Carter have noted that if washing of the wound is carried out before debracketment, foreign bodies may be obscured and will when a tourniquet is used make it more dif-

ficant to differentiate between living healthy and devitalized tissue

The wound is gently repicked and while the drapes are being removed every attempt is made to make the surrounding area, as well as the table underneath, as dry as possible so that there will be no contamination through capillarity when the draping for the definitive procedure is placed. The final toweling is done by the assistant who has in the meantime been preparing himself thus giving the surgeon an opportunity to change his gown and gloves for the consummation of the surgical problem at hand

# OBSERVATIONS FROM STUDY

The present report is concerned with one aspect of the primary care of open wounds, that of cleansing. A program of soap and water washing of wounds to the exclusion of all chemotherapeutic agents has been consistently carried out in 12,044 open wounds over a period of 5 years. Early and repeated rewards in difficult emergencies have given us every encouragement to continue with the adopted procedure. It may be suggested that the establishment of this method of gentle cleansing, as the basic procedure in the traumatic wounds of both industrial and civil practice, be likewise encouraged.

It is to be noted in current reports emanating from the battle-fronts that there are references to thorough cleansing followed by excision of devitalized tissue and the use of sulfonamides as a primary measure. The many enthusiastic reports of successful results following the primary use of sulfonamides may lead to the neglect of surgical asepsis as did the chemical antiseptics of an earlier day. It is quite possible that the use of the sulfonamide drugs as an adjuvant to well grounded methods of surgical cleansing may be attended by still better results. The evidence to date, however, does not suggest that there can be any relaxation in the exacting practices of surgical techniques.

This survey is likewise concerned solely with the problem of industry but it may confidently be stated that the results in civil surgery are comparable. Porter has made mention of the fact that possibly little danger of

tetanus attends the compound injuries of industry. He and others have considered that it was seldom necessary to resort to the use of prophylactic doses of antitetanus serum. A personal experience with 2 cases of fatal tetanus indicates that there is an ever present danger. The first case was a compound fracture of the fifth metatarsal in which tetanus antitoxin was administered upon entry. Tetanus developed some weeks later when the wound had almost healed. The second case resulted from a slight laceration of the tip of the thumb caused by a falling window. These 2 patients were cared for by the iodine and alcohol method. In over 25,000 compound injuries no gas gangrene has been encountered after any of the crushing wounds.

A large percentage of men in industry harbor pathogenic bacteria in the skin, upon entry. It is an everyday experience to see a furunculosis, contact dermatitis, pustular acne, and particularly minute infected burns complicating fresh wounds. Many injuries were on hands, showing evidence of contamination or infection of previous untreated abrasions, punctures, or burns. The exclusion of these infected areas and the proper cleansing of a compound wound in the neighborhood are almost uniformly successful when patient cleansing meets the demands of the situation. Because hand injuries have formed such a high percentage of the total injuries studied, and because the hands are so constantly soiled, and so difficult to clean and to keep clean, they perhaps form the most excellent measure of the efficacy of this method.

It is to be noted from Table II, that in every case of hand infection, one or more

TABLE I

Year	Total injuries	Total compound injuries	Compound hand injuries	Infected hand infections	Infected compound injuries. For total infected other than hand
1931	6,000	2,400	15	4	3
1935	11,100	1,400	1,102	1	1
1937	1,100	1,000	1,100	0	1
1940	4,400	2,000	1,000	1	0
1941	6,100	1,000	1,000	1	1
	21,600	7,800	6,100	10	6

TABLE II.—SUMMARY OF CASES<sup>1</sup>

Diagnosis	Interval between injury and treatment Days	Number of days hospitalized	Treatment	Comments
937				
Celstris dorsum of foot	21		Mastix warm wet dressings	Cases under-treated No permanent impairment
Third degree burn of foot		14	Mastix warm wet dressings	No permanent impairment
Compound fracture both bones of leg			Primary suture after reduction	Infection which did not delay union
Tenosynovitis index fingers	Several		Excision on ulnar side	No permanent impairment
Tenosynovitis thumb fingers			Excision	No permanent impairment
Tumor wrist middle finger	24		Excision	No permanent impairment
Infected elbow thumb			Excision	No permanent impairment
938				
Streptococcus cellulosi pain			Mastix warm wet dressings	Not metal practitioners No permanent impairment
Erysipelas following burn			Burton and sulfonamide	No permanent impairment
939				
Burn perianth buttocks and thigh		24	Tannic acid	Healed without scarring
Compound comminuted fracture 4th and 5th toes			Mastix warm wet dressings	No permanent impairment
Infected ulcer burn	1		Excision	Fracture united No permanent impairment
940				
Infected cellulitis with abscess formation index finger			Excision and drainage	No permanent impairment
Tenony not due from tendon cysts finger			Excision and drainage	20 per cent permanent impairment
941				
Fracture second little finger			Excision and drainage	No permanent impairment
Infected dorsum of hand			Mastix warm wet dressings	No permanent impairment
Cellulitis of leg		19	Mastix warm wet dressings	No permanent impairment
Infected dorsum left hand	8		Mastix warm wet dressings	No permanent impairment

Table shows (1) types of wounds hospitalized, (2) time elapsed between injury and treatment, and (3) type of treatment used

elapsed before the patient appeared for treatment and conversely in 9195 compound hand injuries, there was not a single instance of hand infection requiring hospitalization when the present cleansing method was instituted within a few hours after injury. It can likewise be seen from the table that in no instance was there a septicemia and but one prolonged local infection.

In any case that threatened to be of any severity the patient was immediately hospital-

ized and studied. Aside from the safeguarding of the patient's health, the cost of compensation and loss of time, both to the injured and employer, made it expedient to hospitalize any infection of any severity. This is not to say that we do not encounter more frequent infections. We do. We have many minor infections and wound contaminations with the men continuing at their work if the part lends itself to splinting with a degree of comfort permitting work. These patients are

watched particularly for any tendency on the part of the infection to spread.

While only 2 patients with burns were hospitalized the burns were the greatest source of these minor infections and contaminations. In the light of the conception of a burn as a contaminated compound wound (11), we feel confident that our failures have been due to insufficient cleansing because of punctured, inadequate pressure dressings and to the placing of too much dependence upon tanning agents. We now employ as diligent cleansing methods as in other compound wounds by making the process as painless as possible with local or general anesthesia.

Compound fractures were encountered in 101 patients with 112 fractures with an infection incidence of 4. The majority of these fractures involved the extremities but all parts of the skeleton were affected. There were no cases of osteomyelitis in this series and no cases of delayed union from infection. There was only 1 infection of any magnitude, this occurred in the soft tissues of a both-bone fracture of the leg, but the wound was well healed before the 10th week and the patient walking by the 12th week. These patients were all cared for by doctors in the manner already referred to, and tetanus antitoxin was administered routinely.

There were 445 puncture wounds that received no treatment other than that of a thorough cleansing and debridement at the point of entry and immobilization. No puncture wounds so treated within the first few hours had any subsequent need for hospitalization.

# CONCLUSIONS

The study of 21,862 injuries resulting in 12,044 compound wounds, revealed that hospitalization was necessary in 18 cases in which the primary care consisted of white soap and water cleansing and excision of only devitalized tissue. Seventy-five percent of these compound injuries involved the wrist and hand. Of these 9,105 cases only 10 patients required hospitalization. Because these injuries were so uniformly contaminated and so difficult of cleansing, and further because in no instance was it necessary to hospitalize an individual for infection, we feel that this is the severest test for the efficacy of the method. It is likewise seen that it is successful in the hands of the nurses who care for the great majority of the minor compound wounds. In 101 cases of compound fractures, there were 4 infections and in no instance osteomyelitis or delayed union from infection.

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# THE EXPERIMENTAL PRODUCTION OF GASTRIC AND DUODENAL ULCERS IN LABORATORY ANIMALS BY THE INTRAMUSCULAR INJECTION OF HISTAMINE IN BEESWAX

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THE importance of the digestive action of hydrochloric acid of the gastric juice in the development of ulcer received a forceful impetus from the experimental production of ulcer in the dog, by the diversion of the alkaline bile and pancreatic juice in the Mann-Williamson operation. The obvious distortion of the normal digestive process, by such an operative procedure has sufficed to detract from the full significance of the acid factor in the genesis of ulcer. The transplantation of the duodenal segment, into which bile and pancreatic juice are dumped into the reaches of the lower ileum, creates manifestly the potential for a serious nutritional upset. Yet, Matthews and Dragstedt were able to produce ulcers by attaching a closed fundic pouch to sidetracked ileal loops. Whereas Dragstedt feels disposed to ascribe the origin of ulcer entirely to the acid factor, the large number of investigators who have wrestled with the problem of ulcer including Mann, Ivy and Ochsner and their associates, incline to the belief that trauma and the nervous factor play important roles as well.

This investigation was undertaken to appraise the importance of acid gastric juice as produced by histamine stimulation in the formation of ulcers in the stomach and duodenum.

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About 3 years ago typical duodenal and gastric ulcers were produced in cats and dogs by the intramuscular injection of a histamine-beeswax mixture. That initial experience was reported briefly (22). It is the purpose of this communication to elaborate upon that preliminary account and to indicate that with employment of this simple instrument, viz stimulation of the endogenous mechanism for the secretion of acid, duodenal and gastric ulcer may be produced quite regularly in a large number of laboratory and domestic animals.

## METHOD

In this study prolonged histamine action was obtained by embedding histamine in a beeswax mineral oil mixture. This mixture which melts at temperatures ranging from 40 to 50 degrees C. remains a semisolid mass when injected in the tissues and thus permits a slow and gradual liberation of the embedded histamine. A prolonged, continuous plateau of histamine action is obtained. This method was devised for the study of chronic histamine action (Code and Varco 1940).

*The histamine-beeswax mixture.* The histamine-beeswax mixture was prepared in batches using as a routine 600 milligrams of histamine dihydrochloride (Hoffmann-La Roche). The histamine must be dry before it is placed in the beeswax and, since the dihydrochloride is somewhat hygroscopic, precautions should be taken to keep it moisture free. As a rule sufficient protection from atmospheric water is afforded by keeping the histamine over sulfuric acid in an ordinary desiccator. The histamine is ground to a fine powder in an agate mortar. The grinding is persisted with until

TABLE I—PRODUCTION OF ULCER IN DOGS WITH HISTAMINE-BEE SWAX MIXTURE

Dog No	Weight pounds	Daily dose of histamine base milligrams	No of injections	Results	Remarks
1	35	10	34	Large duodenal ulcer in 1st part of duodenum	No symptoms except fatty stool day before sacrifice
2	30	30	4	Large gastric ulcer on lesser curvature in antrum	Sacrificed when moribund from hemorrhage
3	38	30	21	Four ulcers in duodenum	Died of peritonitis from perforation of an ulcer
4	40	30	17	Superficial erosion in duodenum Two small ulcers on lesser curvature near cardia	Died sacrificed after having hematemesis
5	22	10	31	Small ulcer in antrum	Sacrificed Dog had an erosive gastritis
6	17 1/2	30	31	Duodenal ulcer	Sacrificed
7	24	10	12	Two small ulcers in 1st part of duodenum	Sacrificed
8	35 1/2	30	1	Healing ulcer in 1st part of duodenum	Preparation given this dog for 8 days prior to sacrifice was less active than otherwise used
9	27	30	17	No ulcer	Same as Dog 8 Mammillations and few punctate erosions in antrum
10	27	10	7	Five duodenal ulcers 2 perforated	Expired peritonitis Was pregnant
11	33	30	3	Three duodenal ulcers 1 perforated on pyloric area	Sacrificed because of distemper with bilateral pneumonia pregnant
12	31	30	5	Perforated duodenal ulcer	Expired peritonitis Was pregnant
13	21	30	10	Four superficial ulcers on lesser curvature near cardia	Sacrificed Dog had had left gastric and right and left gastroduodenal arteries ligated

a smooth homogenous powder is obtained. The powder is removed from the mortar and 600 milligrams exactly weighed. The agate mortar and pestle are heated in boiling water, removed, and dried. The weighed histamine powder is placed in the hot mortar and 0.8 cubic centimeter of melted beeswax is added. These are mixed until homogenous, when 2.8 cubic centimeters of hot mineral oil is added.

The contents of the mortar are again mixed until homogenous. While still molten this histamine-beeswax-mineral oil mixture is drawn into 1 cubic centimeter tuberculin syringes which have been warmed and lubricated by rinsing in hot mineral oil. Upon cooling to room temperature, the mixture forms a semi-solid mass which, as a routine, was injected through 20 gauge needles. All doses of histamine

TABLE II—PRODUCTION OF ULCER IN GUINEA PIGS WITH HISTAMINE-BEE SWAX MIXTURE

Guinea Pig No	Size	Daily dose of histamine base milligrams	No of injections	Results	Remarks
1	Adult	5	3	Perforated duodenal ulcer	Expired peritonitis
2	Adult	5	11	Perforated gastric ulcer Duodenal ulcer	Expired peritonitis
3	Adult	5	8	Pyloric 3 duodenal ulcers	Expired peritonitis One duodenal ulcer perforated
4	Adult	5	7	Gastric ulcer on lesser curvature	Expired
5	Adult	5	2	3 duodenal ulcers	Expired few minutes after histamine injection perforated ulcer with peritonitis
6	Adult	5	6	3 duodenal ulcers	Expired peritonitis from perforated ulcer
7	Adult	5	2	No duodenal ulcers	Expired marked postmortem autolysis of stomach
8	Adult	5	5	No ulcers	Expired guinea pig was killed accidentally
9	Adult	Mineral oil and beeswax in equal amounts	15	No ulcers	Sacrificed
10	Adult	Mineral oil and beeswax in equal amounts	15	No ulcers	Sacrificed



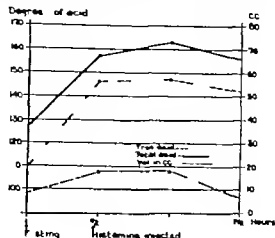


Fig. 1a

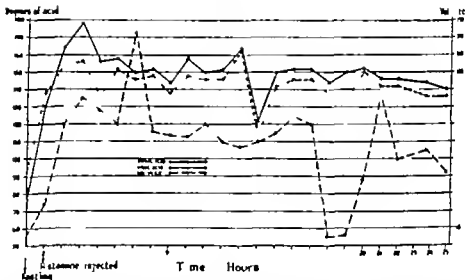


Fig. 1b.

Fig. 1. Graphs of secretory responses to histamine stimulation in dogs. 1a. Gastric pouches. a, Attending subcutaneous injection of 10 milligrams of aqueous solution of histamine. b, Attending intramuscular injection of 50 milligrams of histamine in beeswax. The plateau effect upon the secretion of hydrochloric acid is apparent. Over period of 24 hours, 360 cubic centimeters of gastric

juice with an average free acidity of 30 degrees was produced. This compares favorably to the response to 10 milligrams of histamine, here 36 cubic centimeters of gastric juice with free acidity of 5 degrees was produced. It will be noted that the volume of juice produced after injection of aqueous solution of histamine had returned to the fasting level after 24 hours.

mine mentioned throughout this report are in terms of histamine base. The mixture as prescribed gives approximately 100 milligrams of histamine per cubic centimeter.

As a routine the histamine beeswax mixture was injected once daily in the evening

into the muscles of the back, so that the material was deposited in several pockets along the needle tract. The prolonged histamine action of each batch of mixture was checked by observing the secretion from a Pavlov or Heidenham gastric pouch after injection of a sample

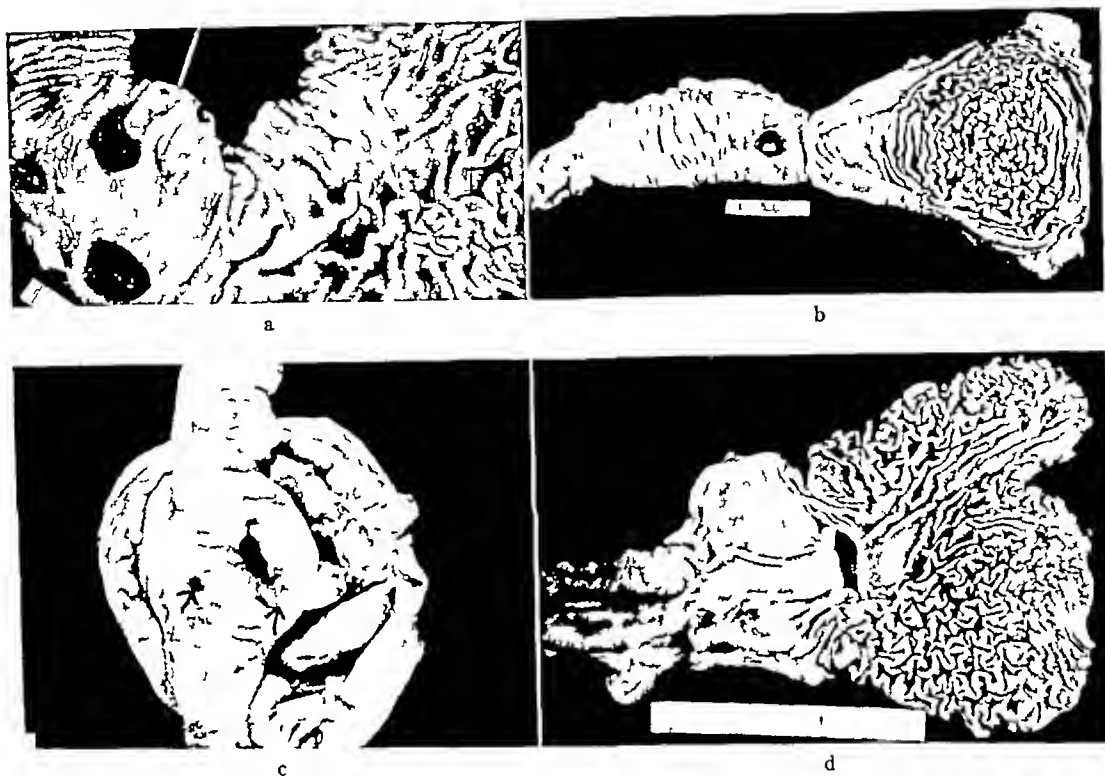


Fig 2 Ulcers produced in dogs by the intramuscular injection of a histamine-beeswax mixture a, Duodenal ulcers with large craters produced in 6 days by the daily injection of 30 milligrams of histamine b, Typical chronic duodenal ulcer with deep excavation produced after 30 daily injections of histamine base c, Perforating jejunal

ulcer and gastrojejunal ulcer in immediate juxtaposition to the stoma (12) These ulcers were produced in a dog with a gastrojejunostomy after 13 daily injections of histamine base d, Large bleeding gastric ulcer (Dog 2, Table I) at juncture of mucosa of antrum and corpus This ulcer occurred after 4 daily injections of histamine base

**Histamine dosage** Adult dogs were given 30 milligrams of histamine base daily in a single injection This dose was the one found to result in a continuous output of acid from Heidenhain pouch dogs, lasting for 24 hours (Table I) The guinea pigs received 5 milligrams of histamine base daily (Table II) The cats were given from 5 milligrams every 2 days to 15 milligrams of histamine base every day (Table III) The chickens were given 7.5 milligrams of histamine base daily (Table IV) The ducks received 20 milligrams of histamine base daily (Table V), the swine 40 milligrams daily (Table VI) The calves were given from 30 to 150 milligrams of histamine base daily (Table VIII), the monkeys from 20 to 50 milligrams daily (Table IX)

**Reactions to the histamine-beeswax mixture** As a rule in the normal intact animals, little

or no effects were seen on the injection of a single dose of the histamine-beeswax mixture In the test dogs, provided with Pavlov or Heidenhain pouches of the stomach, apart from the copious flow of gastric juice from the pouch, the animals appeared normal when given an injection of a properly prepared histamine beeswax mixture Throughout this study only 4 severe histamine reactions were observed Two guinea pigs died of respiratory arrest when injected with a mixture made from histamine powder which had taken up atmospheric water and as a result was apparently imperfectly covered by the beeswax A dog with a gastric pouch, injected with a sample of the same batch of mixture exhibited vomiting and restlessness The gastric pouch was tardy in responding to the histamine stimulus, owing, it was believed, to the shock associated

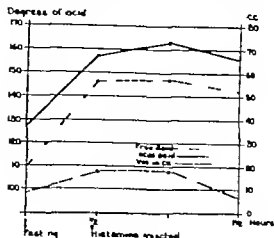


Fig. 12.

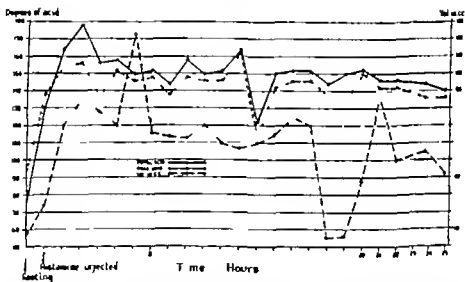


Fig. 6.

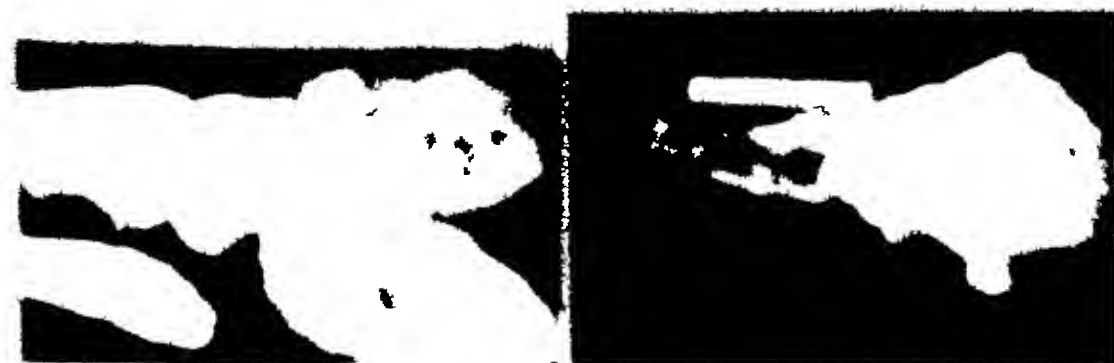
Fig. 6. Graphs of secretory responses to histamine administration to dogs with gastric pouches. a, Attending subcutaneous injection of milligram of aqueous solution of histamine. b, Attending intramuscular injection of 30 milligrams of histamine in beeswax. The plateau effect upon the secretion of hydrochloric acid is apparent. Over period of 24 hours, 369 cubic centimeters of gastric

juice with an average free acidity of .30 degrees was produced. This compares favorably to the response to milligram of histamine, here 30 cubic centimeters of gastric juice with free acidity of .5 degrees was produced. It will be noted that the volume of juice produced after injection of aqueous solution of histamine had returned to the fasting level after 14 hours.

mine mentioned throughout this report are in terms of histamine base. The mixture as prescribed gives approximately 100 milligrams of histamine per cubic centimeter.

As a routine the histamine beeswax mixture was injected once daily in the evening

into the muscles of the back, so that the material was deposited in several pockets along the needle tract. The prolonged histamine action of each batch of mixture was checked by observing the secretion from a Pavlov or Heidenhain gastric pouch after injection of a sample



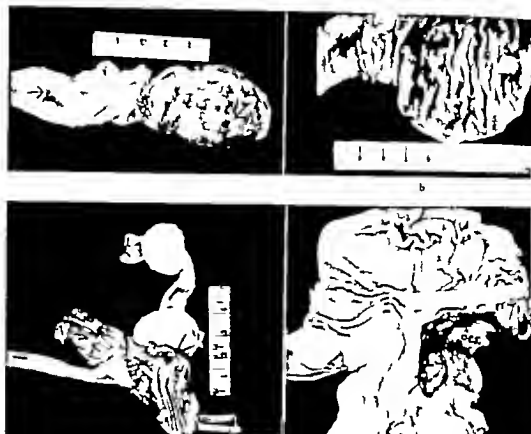


Fig. 3. Ulcers produced in guinea pig, cat, chicken, and beaver by the intramuscular injection of histamine in beeswax. a, Perforated gastric ulcer in the guinea pig; also one large ulcer in the duodenum. Erosions are present in the stomach and duodenum (Table III, No. 1). b, Large perforated gastric ulcer in the cat. The guinea pig lies on the serous side

of the stomach (Table III, No. 2). c, Ulcer in the gizzard of the chicken (Table IV, No. 1). d, Large ulcer in the stomach (Table IV, No. 2). The arrow points to the cardiac end of the stomach in (a). The arrow points to the termination of the esophagus. The arrow points to the pancreas at the site of the perforation.

with the reaction. After an hour the animal had recovered and the pouch secreted at the usual rate. A 3 day old calf developed an asthma like reaction after the injection of 100 milligrams of the histamine-beeswax mixture and died about 12 hours later of pulmonary edema.

When repeated daily injections of the mixture were given some signs of alterations in the gastrointestinal tract often developed. Toward the end of the injection period anorexia and general apathy were not uncommon. In the dog the occasional passage of a tarry stool was seen and on one occasion hematemesis occurred. Increasing experience taught us

that, when the animals became ill, it was likely that an ulcer was present. The experiment was terminated at this juncture by intravenous injection of ether or nembutal. Some of the animals died during the night of perforation.

*Ascertainment of capacity of stomachs to secrete free hydrochloric acid.* In this investigation it was important to determine whether or not histamine evoked an acid gastric secretion in the different animals studied. Examination for the presence of hydrochloric acid in aspirated gastric juice or vomitus was made in most of the animals. Occasionally determinations of free hydrochloric acid were not made until necropsy. Free hydrochloric acid

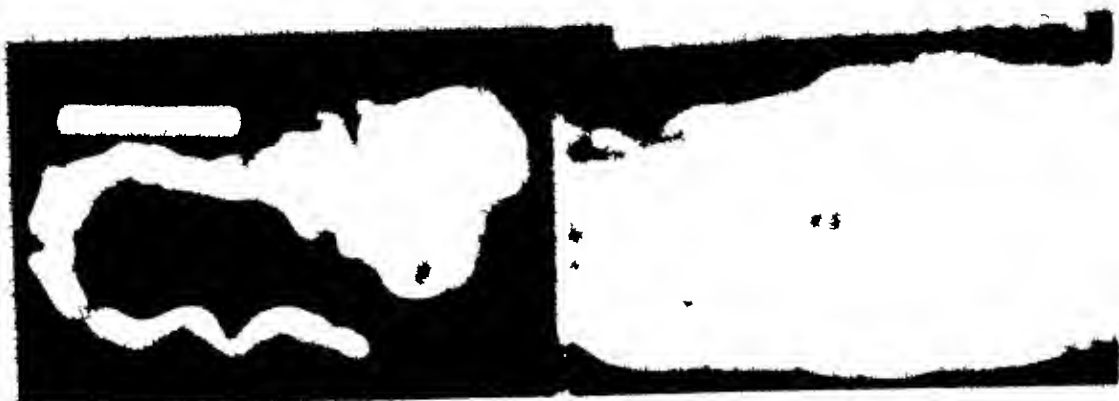




Fig. 5. Histological sections of histamine ulcers (X8). (Table I, Dog No. 1, Fig. 4d.) There is a large area of excavation in the pyloric antrum of the stomach, also thickening of the external serous coat of the stomach.



b (Table III, Cat No. 1). Section cut in juxtaposition with area of perforation. (Table VI, Fig. No. 1). This section was obtained from the indurated edge of an ordinary ulcer.



injections of aqueous solutions of histamine are absorbed rapidly and the effects are of relatively short duration. A prompt response from gastric pouches attends such injections of histamine in dogs, but the effect does not persist for more than 1/2 to 2 hours (Fig. 1a). When histamine is placed in the beeswax mixture a prolonged continuous secretion of gastric juice is evoked. This response has been studied quantitatively by Code and Varco using dogs with Heidenhain pouches of the stomach. During the present investigation this extended action of histamine in beeswax has been verified repeatedly. The intramuscular injection of a properly prepared beeswax mixture containing 15 to 60 milligrams of histamine base is followed within 10 to 15 minutes by a flow of gastric juice. The acidity and volume of gastric juice as collected from the Heidenhain pouches, increase for several hours and the stimulation persists, customarily for at least 24 hours. During this period the total volume secreted expressed as tenth normal hydrochloric acid was usually 1 to 2 liters, the titratable free acidity was between 40 to 150 degrees for the major portion of the period (Fig. 1b). Hypochloremia and dehydration were combatted by the administration of intravenous normal solution dilute salt water *ad libitum* by mouth and the return of pouch secretions by gastric intubation.

**Experimental production of ulcer in various animals.** Following are brief summaries of our experiments.

**Dogs.** Each adult mongrel dog, weighing from 7 to 14 pounds were given 30 milligrams of histamine base daily and of these developed

ulcers, 87 per cent (Table I). Eight animals had duodenal ulcers and in 4 of these the ulcers are multiple. Three dogs showed gastric ulcers. The gastric ulcers occurred in the usual location, on the lesser curvature of the stomach. The duodenal ulcers occurred in the first part of the duodenum (Fig. 2). In general, it can be said that the size of the ulcers varied directly with the length of time over which the daily injections were made; however there was no absolute correlation between histamine dose and size of the ulcer. Though mongrel dogs of any age was not known were used, the younger appearing animals seemed more readily susceptible to ulcer formation; that is, the ulcers developed more quickly as a rule. In the instance of the last dog shown in Table I (No. 3) the three largest gastric ulcers were ligated several weeks before injection and all ulcers developed following the administration of the histamine-beeswax mixture. Three of the dogs were pregnant throughout the period of injection (Table I, Dog Nos. 2, 3, 4). No evidence of ulcer formation was observed in the fetuses.

**Guinea pigs.** Eight guinea pigs were injected daily with beeswax mixture containing 5 milligrams of histamine base (Table II). Six of the 8 developed definite ulcers, 4 had duodenal ulcers, 2 gastric, and had both. One of the remaining animals was killed accidentally on the fifth day and exhibited no evidence of ulcer formation. The other exposed during the night and though no duodenal ulcers are present, the stomach had undergone such marked postmortem autolysis that gastric ulcer could not be ruled in or out. Two control guinea pigs, after receiving the same amount of beeswax and mineral daily for a longer period (5 days) than any of the animals in this series, showed no ulcers.

**Cats.** The experimental production of ulcers in cats employing the histamine-beeswax mixture, has been reported previously. In that series, 8 cats were injected. Ulcers or erosions were observed in all the animals. In the present study 5 cats were injected with varying amounts of histamine in an effort to determine the minimal dose required for ulcer formation (Table III). The 4 cats, receiving from 5 to 5 milligrams of histamine base daily developed

TABLE III—PRODUCTION OF ULCER IN CATS WITH HISTAMINE BEFSWAX MIXTURE

Cat No	Size	Daily dose of histamine base milligrams	No of injections	Results	Remarks
1	Adult	15	16	Perforated gastric ulcer	Expired peritonitis
2	Adult	5	5	No definite ulcer	Sacrificed Several punctate erosions in antrum
3	Adult	5	28	One ulcer and 2 erosions in duodenum	Sacrificed
4	Adult	10	3	Three ulcers in antrum	Expired pneumonia
5	Adult	10	21	Three gastric ulcers	Expired pregnant

TABLE IV—PRODUCTION OF ULCER IN CHICKENS WITH HISTAMINE BEFSWAX MIXTURE

Chicken No	Size	Daily dose of histamine base milligrams	No of injections	Results	Remarks
1	1 lb young	7.5	4	Ulcer in gizzard	Sacrificed
2	1 lb young	7.5	4	Ulcer in gizzard	Sacrificed Many erosions throughout
3	1 lb young	7.5	0	Several ulcers in gizzard	Sacrificed
4	1 lb young	Equal amount of beeswax and mineral oil	0	No ulcers	Control

TABLE V—PRODUCTION OF ULCER IN DUCKS WITH HISTAMINE BEFSWAX MIXTURE

Duck No	Size pounds	Daily dose of histamine base milligrams	No of injections	Results	Remarks
1	6	0	20	Ulcer in gizzard perforated ulcer in duodenum	Expired perforation
2	6	20	26	Four gizzard ulcers	Sacrificed

TABLE VI—PRODUCTION OF ULCER IN SWINE WITH HISTAMINE BEFSWAX MIXTURE

Swine No.	Size pounds	Daily dose of histamine base milligrams	No of injections	Results	Remarks
1	6	40	14	Large ulcer around esophagus pylorus and in duodenum	Large ulcer had perforated onto pancreas and peritoneal cavity
2	25	40	15	Large perforated ulcer around the esophagus	Perforated into localized abscess
3	25	40	13	Large ulcer around esophagus erosion on greater curvature	Hemorrhagic; Several erosions in antrum

TABLE VII—PRODUCTION OF ULCER IN WOODCHUCK WITH HISTAMINE BEFSWAX MIXTURE

Woodchuck No	Size	Daily dose of histamine base milligram	No of injections	Results	Remarks
1	Adult	15	28	Cluster of ulcers in cardia	Sacrificed
2	Adult	20	5	Two perforated kissing duodenal ulcers	Sacrificed—peritonitis
3	Adult	20	30	No ulcers	Sacrificed Antrum shows mammulations and 5 punctate erosions

ulcers (Table III) Cat No 2, after receiving 5 milligrams every other day for 28 days (14 injections) showed no definite ulcers though several punctate erosions in the antrum were noted One of the cats

(No 5) was pregnant throughout the period of injection  
 4 Chickens Three young male chickens received injections of 7.5 milligrams into the subcutaneous



TABLE VIII.—PRODUCTION OF ULCER IN CALF WITH HISTAMINE-BEESWAX MIXTURE

Calf No.	Wt. pounds	Daily dose of histamine base in grams	No. of injections	Results	Remarks
	Approx. 100	200		No ulcers	Two subcutaneous hemorrhages. Esophageal plicae edematous, probably from histamine
	Approx. 11	20	11	Anterior with no true ulcers	Sectored. Anterior shows no ulcers, no in diameter
3	Approx. 135	20 to 7	20	Two active duodenal ulcers, healed antroal ulcers	Sectored, many erosions in antroal
	Approx. 20	15 to 20	20	10 large ulcer and small antroal ulcers	Sectored, hemorrhagic erosions in antroal

TABLE IX.—PRODUCTION OF ULCER IN MONKEY WITH HISTAMINE-BEESWAX MIXTURE

Monkey No.	Wt. pounds	Daily dose of histamine base in grams	No. of injections	Results	Remarks
	4 1/2	20	20	No ulcers	Exploratory gastrostomy and duodenostomy
2	20	20	20	No ulcers	Submucosal hemorrhages 2-3 mm. diameter and superficial erosions, none in diameter larger
	7 1/2	20	20	No ulcers	On lesser curvature ulcers appeared in stomach, not in diameter; other small erosions
4	7	20	21	Gastric ulcer	Sectored

TABLE X.—PRODUCTION OF ULCER IN RABBIT WITH HISTAMINE-BEESWAX MIXTURE

Rabbit No.	Wt.	Daily dose of histamine base in grams	No. of injections	Results	Remarks
Adult	20	16	16	No ulcers	Sectored
Adult	20	44	44	Probable latent erosions of apices of rugae	Sectored
Adult	20	44	44	Gastric ulcer	Sectored
Adult	20	44	44	No ulcers	Sectored
Adult		17 days 24 days		No ulcers	Sectored small hemorrhagic erosions and small ulcers
Adult		20 24		No ulcers	Sectored
Adult		4		No ulcers	Sectored
5	Adult	5	24	No ulcers	Esophageal ulcer, week of duration with total severance limited to post-esophageal tract in esophagus

\*See legend of Figure 94 and section "Examination of Stomach" by dissecting the cellulose pulp of cabbage, carrots, and lettuce and feeding the rabbit only the juice which went through the press, where was produced more copiously with the histamine-beeswax mixture. (B. J. J. and L. L. L., Arch. Surg. 1923, 41, 494)

tissues and muscles of the back and all developed gizzard ulcers in from 4 to 9 days (Table IV). A control chicken, receiving an equal amount without histamine, failed to develop ulcer.

5. Ducks. Two adult ducks, weighing 6 pounds each, were given 20 milligrams of histamine for 20 and 26 days, respectively, and both developed deep gizzard ulcers (Table V). Duck N. In addition showed a perforated duodenal ulcer.

6. Swine. Three swine weighing approximately 50 lbs each, received 4 milligrams of histamine daily over period of 3 to 5 days (Table VI). Each developed large ulcers, 5 or 6 centimeters in

diameter around the entrance of the esophagus. In of these (Nos. 1 and 2) perforation occurred into the peritoneal cavity. In addition, pig No. 3 showed

large hemorrhagic area with necrosis and erosion on the greater curvature. This lesion resembled an infarct—the only lesion in the series which did.

7. Woodchucks. Three adult woodchucks were given 5 and 20 milligrams of histamine daily for from 5 to 5 days. Two developed ulcers (Table VII). One of these animals had a perforated duodenal ulcer and the other gastric ulcer. The third woodchuck exhibited mammillations of the antroal and 5 punctate erosions of the mucosa.

TABLE XI—SUMMARY OF RESULTS INCIDENCE OF PRODUCTION OF ULCER IN THE VARIOUS GROUPS OF ANIMALS

Animal	No in series	Daily amount of histamine base milligrams	No of days	No of ulcers	Per cent
Dogs	12	30	4-37	11	87.5
Guinea pigs	8	5	2-11	6	75
Cats	5	5 q 2 da to 15 day	3-28	4	80
Chickens	3	7.5	4-9	3	100
Ducks	2	20	20-26	2	100
Swine	3	40	13-15	3	100
Woodchucks	3	15-20	5-30	2	66
Calves	4	30 to 150	2-50	2	50
Monkeys	4	20-50	23-59	1	25
Rabbits	8	7.5 to 30	5-41	1	12.5*

\*See footnote to Table A.

8 *Calves* Calf No 1 (3 days old), weighing approximately 100 pounds was given 100 milligrams of histamine and showed immediately, difficulty with respiration and exhibited a tendency to cough. The attack resembled that of asthma in man or "heaves" in horses. By following day, animal had expired. Autopsy revealed a moderate pulmonary edema and lungs did not collapse when thorax was opened.<sup>1</sup>

Calf No 2, weight 125 pounds, received 40 milligrams of histamine for 28 days and developed no ulcers. Mammillations and many erosions, 2 to 4 millimeters in diameter, were present in the antrum.

Calf No 3 was started on 30 milligrams of histamine per day and this was increased 5 milligrams a day until 75 milligram dose was reached. Thereafter, 75 milligrams daily was given. Two active duodenal and 2 healed antral ulcers were found at autopsy.

Calf No 4, weighing 150 pounds, was started with 35 milligrams of histamine and this was increased 10 milligrams per day until 150 milligram dose was given daily, for the remainder of 50 days. Two small antral and 1 pyloric ulcer were found at autopsy.

9 *Monkeys* Four monkeys were injected (Table IX). Monkeys 1, 2, and 3 each received 20 milligrams of histamine daily for 29 days. All appeared in good health at the end of this period. Duodenotomy and gastrotomy on monkey No 1 showed no abnormalities. Injections were discontinued, therefore. In monkeys 2 and 3, daily injections of 40 milligrams of histamine were made for 29 and 59 days, respectively, no real ulcers resulted. Superficial erosions were noted, however, in both monkeys. Monkey 4, which had received no previous histamine injections was then given 50 milligrams daily, for 23 days and developed a chronic gastric ulcer.

10 *Rabbits* Eight rabbits were given 7.5 to 30 milligrams of histamine in beeswax for from 5 to 41 days and ulcers were obtained in only 1 instance

(Table X). It will be noted that 1 of the 3 rabbits receiving 30 milligrams daily for 41 days developed a gastric ulcer. The linear erosions mentioned in Table X were defects along the apices of the rugae.

More recently, mindful of how difficult it is to provide an empty stomach in the rabbit, the cabbage, carrots, and lettuce constituting its diet, have been put through a press. Two rabbits were fed only the vegetable juice. A perforated duodenal ulcer was produced in one, and a long linear perforation along the great curvature, in the other.

#### PATHOLOGY OF EXPERIMENTALLY PRODUCED ULCERS

*Distribution* By location, the ulcers produced in various animals by the histamine-beeswax injections distributed themselves as follows: 18 were in the stomach, 15 in the duodenum, and, in 3 instances, both gastric and duodenal ulcers were present. In the fowl, the usual location of the ulcer was the nonacid secreting mucosa of the gizzard, the homologue of the gastric antrum. In the 3 pigs injected, all the ulcers developed about the esophagus. The pig's stomach exhibits an area of squamous cell epithelium about the cardiac orifice of the esophagus. It appears likely that this epithelium may be more vulnerable to chemical injury than the glandular portion of the mucosa.

In 18 instances the ulcers were multiple, in the 15 remaining instances, a single ulcer was found.

*Gross appearance of the ulcers* On the whole, these experimentally produced ulcers resemble closely those occurring spontaneously in man.

<sup>1</sup>The batch of histamine beeswax mixture from which this dose of histamine was given was later found to be defective due to the use of moist histamine dihydrochloride which apparently allowed a rapid absorption of the histamine from the mixture.

In the main, two types of ulceration were observed: (1) Acute ulceration, accompanied usually by perforation and unattended by induration of the tissue immediately adjacent to the ulcer. In other words, these ulcers exhibited perforation with little or no change in the tissues peripheral to the ulcer. (2) Chronic ulceration with thickening of all the tissues of the wall adjacent to the ulcer. Calloused ulcers with extreme induration were observed in the pigs, and, as before indicated, the ulcers in all 3 of the pigs occurred in juxtaposition to the esophagus. Yet perforation of the gastric wall, onto the pancreas, was observed in 2 of the 3 pigs. Most of the other indurated ulcers occurred in the antrum of the stomach. The edges of the chronic ulcers were demarcated sharply, as a rule, with elevation of the surrounding indurated tissue. The base of such ulcers was covered often with a gray exudate. In several instances there was old blood on the floor of the crater. In the dog followed with more care than the other animals in the series, blood was noted often in the stool and decline of the hemoglobin was usual.

**Microscopic appearance.** As yet, a thorough histological study of the stomach of animals in which ulcer was produced by histamine has not been completed. Whether such ulceration formation is accompanied by an extensive interstitial infiltration of lymphocytes of the antrum as attends spontaneous ulcer in man as a fairly constant accompaniment, has not been determined yet. The appearance of the edge of an experimentally produced ulcer is shown in Figures 5a, b, c, for the dog, cat, and pig, respectively.

#### PREVIOUS ATTEMPTS AT THE EXPERIMENTAL PRODUCTION OF ULCER WITH HISTAMINE

Buechner and Molloy (1927) succeeded in producing erosions and ulcerations in the proventriculus of rats by injecting subcutaneously an aqueous solution of 0.6 gram of histamine per 100 grams of body weight. Buechner, Siebert and Molloy (1928) elaborated upon these findings, pointing out that starving the animals on alternate days increased the incidence of erosions and ulcers. Buerkle de la Camp (1929) confirmed the work of the previous named authors and obtained

the greatest incidence of erosions by injecting the histamine solution 3 times daily, also starving the animals on alternate days. In a footnote on page 49 of his paper Buerkle de la Camp directs notice to the spontaneous occurrence of ulceration in the proventriculus of rats. The incidence of this spontaneous occurrence, however, is considerably less than the quite constant appearance of erosions and ulcerations, noted by Buerkle de la Camp as histamine provocation. In our laboratory observation of such spontaneous occurrence of erosions and ulcers in the proventriculus of the rat dissuaded us from employing that animal as a test subject.

Matsuuda (1931) failed to produce erosion or ulcers in rabbits, dogs, and guinea pigs with injections of large single doses of histamine. When, however, he began with 0.3 to 1 milligram of histamine per kilogram of body weight and increased this dose to 1 to 3 milligrams per kilogram giving 3 injections a day, Matsuuda succeeded in producing erosions and ulcers in the 3 types of animals in which he had failed previously with single injections. Matsuuda shows a photograph of a perforated ulcer in the fundus of the rabbit.

Harde (1932) produced erosions in the stomachs of mice and in a few instances in guinea pigs by subcutaneous injection of small doses of aqueous histamine. The mice were each given 0.25 milligram and the guinea pigs and rabbits 1 milligram of histamine each, per day. Harde failed to produce gastric erosion in the rabbit.

Eppinger and Leuchtenberger (1933) produced shock in dogs by single intravenous injections of large doses of histamine (30 to 60 milligrams). In 4 such animals gastric erosions were observed. In 1 the authors describe the presence of an ulcer, though their Figure 4, shown to illustrate its occurrence, demonstrates excavation as occurring only in the muscularis mucosae—the usually accepted definition of an erosion as contrasted with an ulcer in which the excavation extends into the circular muscle layer of the stomach or duodenum.

Orndorff, Bergh, and Ivy (1935) in a paper entitled "Peptic Ulcer and Anxiety Complex: Failure of Pharmacologically Sustained H

persecution and Hypermotility of Stomach to Produce Chronic Gastric Ulcer in Dogs" carried out a most diligent attempt to provoke ulcer formation with histamine. Ten dogs were injected subcutaneously with 2 milligrams of aqueous histamine every 2 hours, day and night, 10 times a day, the dogs being allowed a 4 hour rest period daily. These injections were continued daily for a period extending up to 66 days. Among 4 of the 9 dogs which survived the experiment, superficial erosions were noted in the duodenum. Heinlein and Kastrup (1938) failed to produce erosions or ulcers in cats with subcutaneous injections of histamine, but did succeed in producing an interstitial submucosal lymphocytic infiltration, which they describe as a gastritis.

McIlroy (1928) reports that he noted the presence of 2 well defined ulcers in the stomach of 1 of 4 cats which had received injections of histamine. This observation led him to attempt to determine whether the administration of histamine would delay healing in gastric mucosal defects created by operation. McIlroy believed, as a result of experiments upon 7 cats, that the healing time, as compared with controls, was prolonged definitely.

O'Shaughnessy (1931) injected histamine locally into the gastric wall of cats and administered histamine subcutaneously twice daily and succeeded in producing 2 chronic ulcers out of trials on 90 cats.

Flood and Howes (1934) undertook a study somewhat similar to that reported previously by McIlroy, on both cats and dogs, using relatively smaller doses than McIlroy. Flood and Howes noted definite delay in healing in previously established antral mucosal defects with histamine administration, no delay in healing of defects high along the greater curvature attended subcutaneous administration of histamine.

#### EVALUATION OF STUDY

A means by which typical ulcers, not unlike those occurring in man, may be produced quite regularly, in a number of the common laboratory and domestic animals, is described. No ulcers appeared in our control animals to which a beeswax-mineral oil mixture was ad-

ministered, omitting the histamine. Nor have we observed the occurrence of spontaneous gastric or duodenal ulcer in dogs and cats in this laboratory. Turck (1916) noted no instances of ulcer in 189 healthy and 82 diseased dogs. Mann (1916) failed to observe the spontaneous occurrence of ulcer in 200 normal dogs and cats. Ivy (1920) observed a pyloric ulcer once in examining the stomachs and duodena of 900 dogs.

Animals vary considerably, with reference to the ease or difficulty with which ulcer may be produced by the intramuscular injection of histamine in beeswax. The guinea pig and cat are probably most susceptible to the development of ulcer formation with histamine stimulation. The monkey and the rabbit are probably the most refractory. Yet, recently, in the rabbit, by employing a diet which would facilitate gastric emptying, ulcers were produced readily by histamine stimulation. Similar studies may afford clues concerning the apparent refractoriness of some animals to the production of a histamine ulcer. It is interesting to note that pregnancy appears to be no deterrent to the experimental production of ulcer by histamine stimulation.

The predominating action of histamine on the gastric mucosa is the stimulation of the acid producing cells. Histamine gives a gastric juice with maximal acidity. It does not give a maximal stimulus to the secretion of pepsin and mucus. It seems highly probable that it was this highly acid gastric juice acting, more or less continuously, over a prolonged period which produced the ulcers in the stomach observed in this study. Likewise, the ulcers in the duodenum seem, most certainly, to have been produced by the overwhelming effects of a prolonged excess of acid gastric juice. Histamine may not afford the same stimulus to the flow of bile, pancreatic juice, and duodenal secretion as it does to the production of acid gastric juice. Thus, an unequal stimulation of those agents which normally counteract and neutralize hydrochloric acid may have contributed toward the production of the ulcers seen in this study. It seems most likely that the acid, inadequately opposed, produced digestion of the gastric or duodenal wall with resulting ulcer formation and all the associated

complications such as serious hemorrhage or perforation as may be seen in ulcer in man.

The regularity with which ulcer may be produced experimentally with histamine lends strong support to the thesis that acid is the important factor in the genesis of spontaneous ulcer in man. The production of ulcer by stimulation of the intrinsic mechanism for the secretion of acid indicates how important an item the effective control of gastric acidity is, in the management of ulcer. The method described herein of producing ulcer is proving in our hands, a very satisfactory instrument to assess the capacity of any operation to prevent ulcer recurrence (12) (see Fig 2c).

#### SUMMARY AND CONCLUSIONS

A method is described by which a prolonged maximal secretion of hydrochloric acid may be provoked from gastric pouches of dogs. This method consists in embedding histamine in beeswax, to permit gradual liberation of the histamine on intramuscular injection of the mixture. With employment of this agency gastric and duodenal ulcer may be produced with some regularity in a number of common laboratory and domestic animals. These ulcers lend every appearance of being not unlike the ulcers which occur spontaneously in man.

The experimental production of ulcer in this manner furnishes additional testimony to the great importance of acid in the genesis of ulcer. This method of producing ulcer experimentally provides a simple means of evaluating the worth of therapeutic agents in retarding or influencing favorably the healing of

ulcer. In addition, it affords the surgeon a method of determining experimentally what operative procedures performed upon the stomach for the relief of ulcer may thwart the ulcer diathesis and obviate recurrence of ulcer after operation.

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(a) 10 tablets of 1 gram each, 4 to be taken by mouth at time of injury and 1 every 4 hours thereafter (b) 3 to 5 grams of the powder form to be introduced into the wound itself whenever possible on the battle field immediately after the injury while transportation is awaited.

When a tourniquet is found necessary it must be tied tightly enough to compress the artery but no tighter. If tied too loosely the artery may be partially open and the veins completely blocked, thus resulting in increased rather than decreased bleeding. Tourniquets below the knee or below the elbow are contraindicated, since the two bones prevent complete control of the interosseous arteries. Intractable and copious bleeding at the wrist has completely ceased following the removal of a tourniquet on the lower arm. As Mitchner the English surgeon suggests the exact time and fact of the application of the tourniquet must be recorded on the patient's forehead a strip of adhesive being used. As the patient is being transported to the rear the tourniquet must be loosened when possible and feasible every hour and the fact and time so recorded on the forehead.

The experiences of Allen and Brooks with the survival of tissues deprived of their blood supply and cooled to 5 degrees C., prompts the suggestion that if ice could be made available from refrigerating units near the front line such tourniquetted limbs should be packed in ice bags before and during transportation. The tourniquet could then remain in place for 5 to 6 hours without harm to the tissues. Moreover the reduced temperature of the injured limb provided by packing in ice bags would also have the effect of inhibiting bacterial growth in the wound, of reducing shock imposed by injured tissues and of providing absolute comfort during transportation. An additional advantage of great importance would be the possibility, after 3 to 5 hours of being packed in ice of performing a débridement on arrival at an evacuation hospital without the necessity of anesthesia. Tissues deprived of their blood supply and cooled to 5 to 7 degrees C are anesthetic to pain. Such débridement must be particularly thorough following such re-

frigeration. Every precaution should be taken at the time the tourniquet is applied to leave all recesses of the wound well impregnated with sulfonamide powder to ensure complete inhibition of all bacterial growth.

Bleeding from wounded arteries is governed by many diverse factors. A tangential wound in an artery usually bleeds intermittently to the death of the animal whereas a completely severed artery will bleed profusely for a few moments and then cease entirely as the elasticity of the arterial wall gradually withdraws the vessel from the site of injury and envelops the severed end in a mass of adventitia (Fig. 1). For example, a tangential wound of the left femoral artery in animal 1 bled for 20 minutes until the death of the animal whereas a completely divided right femoral artery in the same animal bled only 5 minutes. The amount of blood lost from the incompletely severed left artery was 203 cubic centimeters, but only 45 cubic centimeters were lost from the completely divided right artery. In animal 2 a tangential wound of the right femoral artery bled 7 minutes to the death of the animal with the loss of 300 cubic centimeters of blood. The completely severed left femoral artery bled only 1 minute with the loss of a paltry 30 cubic centimeters of blood (Fig. 1). The would-be suicide frequently fails because he completely severs the radial artery whereas a partially severed artery might have accomplished his purpose.

Suturing of the wounded artery is considered by many surgeons including von Haberer as definitely indicated (when possible) in injuries of the larger vessels such as the common carotid, subclavian, axillary, brachial, common and external iliac, femoral, and popliteal arteries. Suture should not be performed in those instances in which the artery can be permanently ligated without harm as for example the external carotid, either radial or ulnar arteries, and anterior or posterior tibial arteries. Mitchner warns that reparative surgery even of large vessels has a very limited field. He states "Under war conditions the results of such reparative vascular surgery are notoriously disappointing. The tyro or inexperienced surgeon is apt to spend unavailingly much precious time in

attempting the repair of vessels better ligated. It may be questionable in the rush of a casualty hospital if it is justifiable to take considerable time over an operation on one subject, the results of which are considerably in doubt, while many other urgent cases call for prompt attention from the surgeon."

Mitchner further observes that in the last war, in approximately two-thirds of the cases in which repair operations were employed, one of these limbs was lost, although not one-third of the cases maintained their circulation through the site of operative repair. However, 3 years later, those patients in whom repair was accomplished, but whose vessels had thrombosed, were well and working, whereas almost all those in whom immediate suture had been successful now had aneurysms at the site of operation, requiring ligation of vessels and excision of the sac before a useful limb was obtained.

Such observations are, indeed, discouraging as to the value of ever attempting the repair of an injured vessel. A small, clean cut, longitudinal laceration, or a transverse cut involving less than one-third of the circumference of the artery might be advantageously sutured. The local application of the sulfonamides might be expected to reduce postoperative thrombosis, thus averting some of the objections voiced by Mitchner. It need not be pointed out that conditions for such arterial suture must be as perfect as possible: absolute asepsis, proper instruments and facilities and the availability of heparin, continuously administered for at least 24 hours after the operation, to reduce postoperative thrombosis at the site of suture. Unless ideal conditions prevail, it would seem preferable to control bleeding by ligation of the injured artery at once, particularly if the laceration is a jagged one or if loss of substance makes an end-to-end suture necessary. Such ligation should be performed at two points above and below the injury, and the artery completely divided. Double ligation in continuity is preferable to ligation at the site of division since erosion of the vessel wall at the site of ligation is always a real danger when a large artery is ligated in continuity. Complete

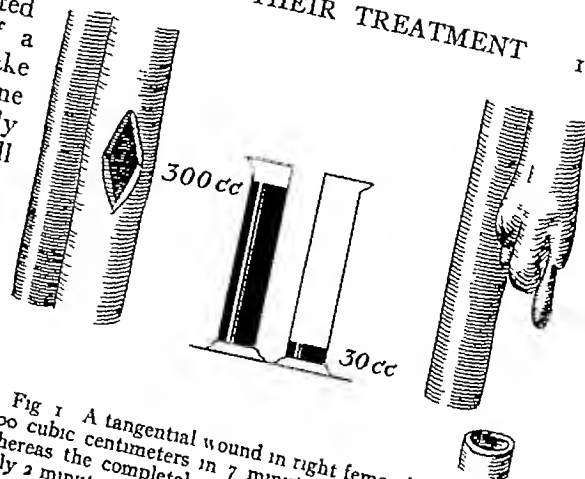


Fig 1. A tangential wound in right femoral artery bled 300 cubic centimeters in 7 minutes to death of animal, whereas the completely severed left femoral artery bled only 2 minutes with loss of only 30 cubic centimeters, due to retraction and envelopment of the severed end in a mass of adventitia.

division permits retraction and shortening of the vessel due to its elastic elements, thus producing a thickened vessel wall. This was shown experimentally (12) by double ligation of the abdominal aorta in a dog and division between the ligatures. The two ends retracted until they were separated 3.8 centimeters with perceptible thickening of the proximal aortic wall. It was evident, as one observed the pulsating proximal end, that the force of each pulsation was distributed over a wide area and was dissipated in expanding and lengthening this thickened blind end (Fig 2). When ligation of the abdominal aorta was performed in continuity, it was equally evident that the maximum force of each pulsation was concentrated at the site of ligation, which, being a fixed point resulted in a widening and expansion of the vessel wall only, and not in its lengthening. The constant battering of the pulse beat against the fixed point of ligation leads first to microscopic and molecular rupture of cells, followed by a gradual macroscopic erosion of the vessel wall. Ligation in continuity also invites reopening of the vessel lumen at the site of ligation. A ligature tied sufficiently tight to occlude an artery and shut off flowing blood will cause necrosis of all the tissues included in the ligature (Halsted). Envelopment of the ligature and its included tissues in exudate, fibrin, and eventually fibrous tissue, usually



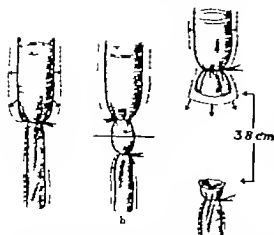


Fig. 1. a, Ligation in continuity invariably leads to necrosis of the included vessel wall, and rupture if the vessel is large, due to constant battering of the blood stream against fixed point. b and c, Ligation at fixed point leads to marked retraction of the proximal stump, thickening of the vessel wall. The force of each pulsation is dissipated in both lengthening and kinking of the vessel, and as this force is not concentrated at site of ligation the danger of rupture is almost nil, regardless of size of vessel.

prevents fatal rupture. Occasionally necrosis of tissue may lead to partial cutting through of the ligature resulting not always in perforation but more frequently in partial restoration of the artery—a disappointing sequel to ligation in continuity. When ligation in continuity is found imperative graduated ligatures paralleling the size of the artery must be used (Ballance and Edmunds Reid, 27) e.g. tape ligatures on the aorta or innominate artery; heavy braided ligatures of silk on the iliac or subclavian arteries; and smaller braided silk on the femoral and carotid arteries.

Pearse has recently advocated the employment of unsurfaced cellophane as a desirable material to place around large arteries, instead of complete ligation with silk. The cellophane produces a circular fibrous reaction which gradually occludes the vessel. Because of recurrence of murmur and symptoms Gross, in ligation of the patent ductus has recently employed an encircling band of cellophane as well as two ligatures of silk to ensure permanent cicatricial closure of the ductus.

When a vessel is to be ligated and divided the ligature need not be graduated to the size

of the vessel but needs to be only large enough to permit the tying of the ligature without its breaking. In the ligation of a large vessel, the lumen should first be emptied by stopping the artery of blood its refilling during ligation being prevented by digital pressure on both sides of the site of ligation (Reid, 27). This ensures the application of the ligature on a relaxed vessel instead of on a fully distended vessel thus avoiding a fracture of the wall.

A further argument against ligation in continuity is suggested by the observations of Leriche and Werquin. They believe that the severe trauma imposed upon the periaortic sympathetic plexus by the ligature produces a reflex vasoconstriction in the arterial bed distal to the ligature thus obliterating or closing potential collaterals. Furthermore, Mitchiner observes that unless an artery is completely divided vascular disturbances may develop years later characterized by pain, poor pulse and claudication in the affected limb—symptoms which are completely relieved by division of the fibrous cord at the site of previous ligation or repair.

In those rare instances in which repair of a wounded artery has been attempted, the wound in the soft tissues should be closed without undue tension, the part should be elevated, and a splint should be applied to ensure rest. Such a splint should be worn at least 14 days (Mitchiner). The patient is not allowed out of bed for a month from the time of arterial suture.

The problem of whether ligation of the accompanying vein is desirable whenever a large artery is ligated for simple arterial lesions is still subject to controversy. Prompted by experiences in the early part of World War I, the Interallied Conference of Surgeons held in Paris in May, 1917 recommended that the ligation of a large artery for injury should be accompanied also by the occlusion of the satellite vein even though the latter be uninjured.

Reichert, in ingenious replantation experiments on dogs, demonstrated that following the division of all tissues of a limb except artery, vein, bone and nerve and their immediate reanastomosis the artery alone to the replanted limb could not be ligated until the

14th day following replantation without precipitating gangrene, whereas, when the vein was ligated simultaneously with the artery, the ligation of the latter could be performed as early as the 7th day following replantation without gangrene. This evidence, amid the welter of many inconclusive experiments (Mulvihill, Harvey, and Doroszka, and Wilson), proves beyond the slightest doubt the beneficial effect produced upon the nutrition of a limb by the simultaneous ligation of artery and vein.

In a clinical study by Sehart, it was found with reference to the lower extremity, that ligation of the artery alone was followed in 20 per cent of his cases by gangrene, whereas ligation of both the artery and vein was followed in only 9 per cent by gangrene. With reference to the upper extremity he found that ligation of the artery alone resulted in gangrene in 7.8 per cent of the cases, and that ligation of both artery and vein resulted in no gangrene. He attributes the larger incidence of gangrene in the lower extremity to the absence of large muscle masses bridging the knee as compared with those bridging the elbow.

In a statistical summary by Heidrich, we find that among 995 ligations of the large arteries alone, gangrene occurred 154 times—a percentage of 15.5—and among 198 ligations of both artery and vein, gangrene occurred 17 times—or a percentage of only 8.5.

With these facts before us, there would seem to be no doubt that ligation of the vein is indicated whenever one of the large arterial trunks requires ligation.

An exception to this rule occurs in the presence of the so called Henle-Coenen phenomenon (Pemberton). If, following ligation and division of an artery, the distal arterial stump is seen to pulsate, (conclusive evidence of adequate collateral circulation) the vein need not be ligated. If no such distal pulsation is observed or felt, the vein should also be ligated.

A false or sacculated aneurysm is not infrequently encountered as a later development of simple arterial injuries. Ligation of the vessel above and below the lesion with extirpation of the sac when feasible is an ac-

ceptable procedure, accompanied usually by ligation also of the accompanying vein. Restoration of the artery by suturing of the rent according to the method of Matas is the operation of choice when technically possible.

Injuries producing direct communications between artery and vein are particularly inimical to the later health of the patient. The diagnosis of such a lesion is usually quite simple. The injury is accompanied by profuse but easily controlled bleeding, and by the prompt development of a thrill and bruit continuous throughout the cardiac cycle. Occasionally, the appearance of the thrill and bruit is delayed for several hours, or even days, due probably to the temporary occlusion of the abnormal communication by a blood clot. If sufficiently large, the fistula will ultimately lead to profound circulatory effects, namely, dyspnea and tachycardia on the slightest exertion, an increasingly vigorous beating or "pounding" of the heart, a slowly developing decompensation due to a dilating heart, followed inevitably by complete invalidism and death. In several patients, extraordinary momentary faintness, relieved by sitting or falling down, has been observed—a symptom referable to a failing circulation. In addition, there may follow in the wake of a fistula various local manifestations, such as edema, often elephantiasis in type, marked varicosities complicated by eczema and ulceration, and occasionally gangrene.

With these possible developments before one, there can be little doubt that a fistula must be eliminated from the circulation. If seen immediately after the accident producing an arterial injury, the patient should be placed in a hospital for observation. If, under bed rest, the bleeding ceases, and there is no increase in the swelling of the limb due to an enlarging hematoma, nor evidence of developing infection, further delay in operating is advisable. On the other hand, an increasing hematoma at the site of the injury, or an increasing swelling of the limb which threatens the blood supply of the extremity beyond it, as shown by a cold, edematous, and pulseless leg, requires immediate operation. The operation is preferably done under a tourniquet, the hematoma is evacuated, a localized dé-

bridement performed, and the injured vessels exposed. In the absence of any evidence of infection a suture of the arterial wound may be attempted. The vein is ligated to avoid the danger of an embolus either of air or blood clot. If such suture is impossible the ligation and division of artery and vein is in order. Repeated and massive transfusions are indicated to maintain and raise peripheral arterial pressure since this is the best guarantee that a limb deprived of its main artery will survive. Interruption of the lumbar sympathetics will encourage collateral circulation by promoting vasodilation. This may be done by novocain and alcohol injection of the lumbar or thoracic ganglia, or by direct operative interruption if the lower abdomen is opened for injuries to iliac vessels (5).

Should evidence of infection be present, the hazard to life is greatly increased. Under a tourniquet, the wound is laid wide open, blood clots are removed, a débridement is performed, the injured portions of the artery and vein are excised, and the 4 ends of the vessels are ligated. The wound is left widely open and Dakin's solution is introduced at hourly intervals. In a contaminated, though not grossly suppurating wound sulfathiazole liberally employed is preferable to dakinization. Sulfonamides by mouth are given liberally.

If the wound to the artery appears trivial and the diagnosis is not immediately made (and this is often the case) operation should be deferred until all danger of infection is over. Indeed, the observation that small fistulas heal spontaneously has led Reid (26) to advocate postponement of surgical intervention for 6 months. Experiments have shown however that only small fistulas tend to heal spontaneously and that large fistulas do not (11). If therefore evidence develops that the heart is enlarging that the thrill and bruit are increasing rather than diminishing in intensity that variations in blood pressure and pulse can be produced by closing the fistula, and that these variations are becoming more rather than less pronounced, one may be certain that the opening will not close spontaneously and that it must be eliminated by operation to avoid further ill effects upon the circulatory system.

Reid emphasizes further that delay is operating upon a recently formed fistula indicated so that the collateral circulation may be developed sufficiently to permit division of the artery if necessary. This delay may be as short as 5 to 6 weeks or as long as 3 to 4 months without the life of the patient being endangered. Other benefits of delay suggested by Reid are that the injured vessels become more thoroughly healed, thus making their dissection easier and safer and infection is less likely to occur. As recorded by Miles, such delay may occasionally be accompanied by a rapid development of cardiac decompensation. In his case of a left subclavian fistula, marked symptoms of circulatory embarrassment were noted within 9 weeks after the injury which had produced the fistula. Excision of the fistula restored the heart to approximately normal function.

An important preoperative precaution is long standing fistula is to prescribe complete rest in bed for 10 days to 2 weeks preceding the operation. Pronounced cardiac decompensation with ascites and hydrothorax may entirely disappear with simple rest (15). Digital closure of the fistula itself or of the artery proximal to the communication for 30 to 40 minutes 3 to 6 times daily will be very helpful in controlling decompensation. It will also I believe reduce the amount of blood flowing through the fistula by encouraging fibrous contraction about the fistula. Several patients were greatly improved before operation by this simple expedient, as shown by some diminution of the greatly dilated heart and by a definitely reduced effect upon blood pressure and pulse by closing the fistula.

Following the operative closure of a large fistula which has produced a marked dilatation of the heart, it is important to restrict activity for 6 to 8 weeks to permit the previously dilated and thinned out cardiac musculature to become readjusted to the increase in diastolic pressure brought about by closure of the fistula. An important precaution at the operating table is also related to this extreme dilatation of the heart accompanying a large fistula. Closure of the fistula not only raises diastolic pressure by an increase in peripheral resistance, but also leads

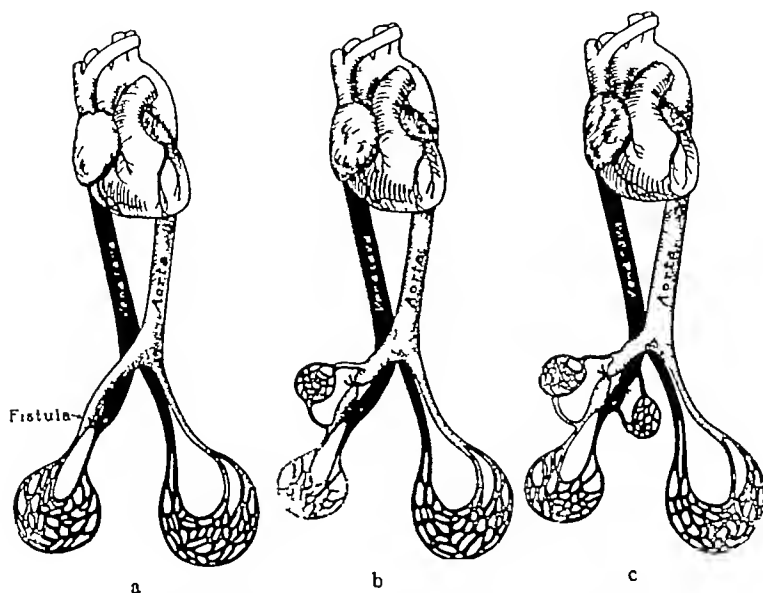


Fig 3 a and b, Ligation of the artery proximal to an arteriovenous fistula is absolutely contraindicated, as all blood passing through collateral vessels will be diverted through the fistula back to the heart, resulting in gangrene of the part distal to the fistula c, Ligation of both artery and vein proximal to the fistula is also contraindicated Gangrene may not result, but the fistula remains active and is not cured Ligation of artery and vein proximal and distal to the fistula with excision of the fistula is the treatment of choice

to an overdilatation of an already dilated heart through a redistribution of the circulating blood, more than half of which formerly leaked into the capacious venous bed. Such overdilatation of an already thinned out cardiac muscle might easily lead to recurrence of the cardiac decompensation. This would be shown by an increased pulse rate and a lowered blood pressure on closure of the fistula, instead of the reverse. The operator should be prepared, should this occur, to do an immediate venesection in order to reduce the volume of circulating blood which has become considerably augmented during the lifetime of the fistula (13).

In an operation upon a fistula, certain fundamental principles must be observed. Ligation of the artery alone, proximal to a fistula, is so utterly disastrous that when confronted with an aneurysm it is most important that accurate studies be made to determine whether the lesion is a simple sacculated aneurysm or an arteriovenous fistula. Life itself may depend on the correct differentiation between these two conditions. It seems

highly probable that the gangrene following ligation of an artery for a supposedly simple aneurysm has occasionally been due to the fact that the arterial injury communicated with a vein and that such a communication was not recognized.

The distinctive features of a fistula as compared with a simple aneurysm are (a) The thrill and bruit are continuous but intensified during systole, (b) the slowing of the pulse and rise in blood pressure on digital closure of the artery proximal to the lesion occur only in the presence of a fistula and never in the presence of a simple arterial aneurysm, (c) the high oxygen content of arterial blood withdrawn from the veins distal to a fistula as compared to venous blood obtained elsewhere is a distinguishing feature suggested by Brown.

If the venous communication is overlooked, and the usual Hunterian ligation of the artery proximal to the aneurysm is performed, gangrene beyond the aneurysm is almost inevitable. The collateral circulation will find its way, not into the capillary bed distal to

the fistula but through the fistula back to the heart (Fig. 3).

The ligation of the artery and vein proximal to the fistula may occasionally be employed as a preliminary procedure in the hope that thrombosis will occur at the site of the fistula. Usually the fistula is not cured, as the collateral channels will readily supply blood to the site of decreased resistance provided by the fistula. In Gilcreest a interesting case the subclavian artery and vein were ligated proximal to a subclavian fistula with some improvement. A year later ulceration and rupture of a large surface vein of the forearm led almost to a fatal hemorrhage. The thrill and bruit were present as before the arm was still swollen and the veins were still enormously dilated. Ligation of the artery and vein beyond the fistula by me was followed by complete cure.

The ligation of the artery and restoration of the vein is definitely contraindicated. This may lead to gangrene due to the great disproportion between a dilated, tortuous venous system and the meager collateral arterial circulation. The little blood that passes through the collateral arterial bed finds its way promptly into the dilated venous bed, without flowing into the distal arterial bed.

In the surgical treatment of long standing fistulas, transvenous or transarterial aneurysmorrhaphy may be attempted. Under a tourniquet, the varicose sac or the dilated vein is boldly opened, and the rent in the artery is closed by suture. The vein should be ligated above and below the fistula. The wall of the vein may be employed to reinforce the sutured rent in the artery.

Ligation of the artery and vein proximal and distal to the fistula with excision of the fistula is the operation of choice and the one most easily executed. An artery that is full of blood and pulsating is so much more easily identified than a collapsed vessel that isolation and mobilization of the vessels is best accomplished *without* a tourniquet, the artery proximal to the fistula being isolated first for closure in case of bleeding. If feasible one should be prepared to apply a tourniquet at any time in the course of the operation. If not the artery distal and proximal to the

fistula or to the aneurysmal sac must be exposed first for control with a temporary suture. Should complete mobilization and excision of the fistula be impossible because of involvement of important structures such as nerves, ligation of the artery and vein proximal and distal to the communication is in order. Under such conditions, however the artery proximal to the fistula should be ligated and divided to avoid reactivation of the fistula by the reopening of the artery ligated in continuity through necrosis of the tissues included in the ligature.

Our discussion so far has been directed mainly to a consideration of the effect of ligating the large vessels leading to the extremities. There remains also the question of ligation of the common or internal carotid artery. This procedure is frequently followed by a hemiparesis of the opposite side, due to nutritional disturbances in the cerebrum (31). Additional clinical phenomena that have been observed following ligation of these carotid vessels are convulsions, drowsiness, corn cardiac and respiratory irregularities, fall in temperature, blindness, diplopia, and motor and sensory losses on the opposite side. We gathered together 600 cases of ligation of the common carotid artery, 32 per cent of which presented cerebral symptoms.

Arguing by analogy from the better results obtained in ligation of both vessels in the extremities. Makins very emphatically advised occlusion of the jugular vein whenever ligation of the common or internal carotid arteries is considered. I have followed this rule in two ligations of the common carotid and in two ligations of the internal carotid without the development of cerebral symptoms, even in a patient 68 years of age. Halsted held that ligation of the common carotid artery could be performed with impunity in the young and that the incidence of cerebral disturbances following ligation of the common carotid increased with age.

It is important to note also that Thompson presents evidence indicating that when circumstances demand ligation of the innominate artery it is well to ligate also the common carotid artery. He found that only 41 per cent of 17 cases recovered following ligation

of the innominate alone, whereas 66 per cent of 12 cases recovered following ligation of both the innominate and carotid arteries. He contends that ligation of the carotid artery is indicated because "it diminishes still further the flow of blood through the aneurysm and thereby promotes consolidation, and it prevents an excessive drain of blood from the circle of Willis, thus avoiding cerebral anemia." The ligation of both carotid and innominate arteries would probably increase the percentage of subsequent gangrene in the limb unless the innominate or subclavian vein were also ligated.

The success of operations upon the large vessels depends in great measure upon the avoidance of sepsis. The strictest precautions against infection must be followed throughout, particular attention being paid during a prolonged operation to exclude the skin from the operative field. The liberal use of the sulfonamides locally and systemically is indicated in any contaminated or potentially infected wounds. Drainage in vascular surgery must be scrupulously avoided. It cannot be too emphatically stated that in surgery of the large vessels, the *packing* or *drainage* of wounds is inviting almost certain disaster. Should the wound at any time following operation fill up with fluid, it is a simple matter to evacuate it under strictly sterile precautions.

#### SUMMARY

1. In *contusion* of an artery localized segmentary spasm may occur which may disappear spontaneously in 24 hours. Treatment consists of débridement of surrounding traumatized tissue and a periarterial sympathectomy proximal to the spasm.

2. In *contusion* of an artery localized thrombosis and subsequent embolism may occur resulting in distant gangrene. Or the contused artery may rupture producing shock, or death, from secondary hemorrhage. Or a pulsating hematoma may follow late rupture and hemorrhage into surrounding tissues, leading eventually to the formation of a sacculated aneurysm. Treatment consists of exposure of the artery, and if contused, ligation above and below the contusion is indi-

cated with excision of the contused or thrombosed segment.

In extensive injuries, immediate ligation of large vessels may be mandatory, if prolonged transport is necessary. If transport facilities are good, bleeding may be controlled with Esmarch tourniquet. The wound itself should be well impregnated with sulfathiazole powder, accompanied by the oral administration of sulfathiazole. If ice is available a tourniquetted limb should be surrounded by ice bags and cooled to 5 degrees C. Such a cooled limb may remain tourniquetted for 7 to 10 hours without endangering its viability. Such cooling reduces shock, inhibits bacterial growth, ensures comfort during transportation, and permits débridement without anesthesia on arrival at hospital.

Bleeding from a completely severed artery may be trivial due to retraction of vessel. A tangential wound of even a small artery may bleed interminably to death.

The suturing of a wounded artery is notoriously disappointing because of immediate thrombosis. Should the suture on rare occasion be successful, the late development of aneurysm and pain is the usual end-result. When suturing is attempted, conditions must be ideal, and heparin should be available for 24 hour continuous administration.

Ligation and division of large arteries is preferable to ligation in continuity due to possibility of erosion of the vessel or of re-establishment of lumen through partial necrosis of included tissues. Ligation in continuity may be followed years later by pain, poor pulse, and claudication in the affected limb, relieved by division of the fibrous cord at the site of previous ligation.

The vein accompanying a large artery should likewise be ligated if the artery requires ligation.

Injuries to both artery and vein producing a fistula may be followed as late as 25 years by cardiac dilatation and decompensation. Hence a fistula must be excised, with ligation of artery and vein proximal and distal to the communication. Ligation of artery alone proximal to a fistula is inviting the almost certain disaster of gangrene. Restriction of activity for 5 to 6 weeks is imperative follow-

ing excision of a fistula to avoid cardiac strain due to increase in peripheral resistance through elimination of the fistula.

The introduction of drains into a wound containing sutured or ligated vessels must be scrupulously avoided

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# POSTOPERATIVE THROMBOSIS AND EMBOLISM

## Their Treatment with Heparin

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POSTOPERATIVE venous thrombosis and pulmonary embolism are complications which always prolong the patient's convalescence and may rob him of his life, which otherwise might have been saved by a successful operation. Although neither of these complications occurs frequently, they are encountered sufficiently often to be of considerable clinical importance. Many forms of therapy have been suggested for their prevention as well as treatment, but as yet none of these suggestions has given entirely satisfactory results. Interest in thrombosis and embolism has been renewed during recent years because of various new therapeutic suggestions which have been offered. Prominent among these suggestions has been the use of heparin, which will be discussed later.

### NATURE OF THE STUDY

In order to ascertain the scope of the problem with which one is confronted in the attempted prophylaxis and treatment of postoperative venous thrombosis, thrombophlebitis, and pulmonary embolism, and to learn something of the incidence and significant etiological factors of these conditions, a comprehensive statistical study was made of a large series of surgical cases (1). The records of a consecutive series of patients who underwent various surgical procedures during a 13 year period were reviewed, and the incidence of pulmonary embolism and thrombophlebitis was recorded. There were 1,665 cases of thrombosis or embolism in the entire series, or a percentage of 0.95. In this group of 1,665 cases there were 938 cases of thrombophlebitis and 897 cases of pulmonary embolism, in some cases both conditions occurred. Actually, the

incidence of these complications probably is somewhat higher than these figures indicate, because some instances of mild thrombophlebitis or small pulmonary emboli undoubtedly were not recognized clinically. In the total group there were 343 cases (20 per cent) of fatal pulmonary embolism. Although in general the incidence of fatal pulmonary embolism is not high, the condition is of sufficient gravity when it does occur to make it worthy of serious consideration.

### *Relationship of type of surgical procedure to incidence of thrombophlebitis and embolism*

By a determination of the relative incidence of thrombophlebitis and pulmonary embolism after various types of surgical procedures, certain factors are noted which appear to be significant in the development of these conditions (Table I). The site of operation apparently bears some relationship to the incidence of phlebitis and embolism, because operations performed on the extremities, trunk, head, neck, and thorax are followed by thromboembolic phenomena less often than are those performed within the abdomen. An observation of this type is of importance primarily because of the light which it might shed on the etiology of thrombosis and embolism. Probably there are numerous reasons which account for this fact, some of which may be a shorter period of confinement in bed, distance of operative field from the usual sites in which thrombosis occurs, lesser degree of trauma to large veins, less interference with respiratory tract during the postoperative period, less effect on postoperative rate of venous flow, and so forth. The fact that the extent of the surgical procedure is not the only factor of importance is illustrated by the observation that thrombosis and embolism after radical amputation of the breast, which certainly is an extensive surgical procedure, occur less

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TABLE I —RELATIVE INCIDENCE OF THROMBOPHLEBITIS AND PULMONARY EMBOLISM AFTER VARIOUS TYPES OF SURGICAL PROCEDURES

Operations on	Cases	Clinical diagnosis		Pulmonary embolism			
		Thrombophlebitis		Total		Fatal	
		Number	Per cent	Number	Per cent	Number	Per cent
Head and neck	20,844	29	0.1	53	0.6	14	
Extremities and trunk	18,830	29	0.1			11	
Thorax	3,279		0.1				
Radical removal, breast	3,810	24	3.9	1	2.6		
Exploratory laparotomy for inoperable malignancy	5,117	20	3.0	29	7.9	17	
Resection, stomach (mostly carcinoma)	6,126	23	3.7	21	3.6		0
Other gastric operations (mostly benign)	10,726		0.9	29	0.9	13	
Gall bladder and ducts	6,406	143	2.9	19		27	0
Abdominal hysterectomy	3,730	26	2.1	27	3.1	43	
Splenectomy	261	20	3.6		3.2		
Appendectomy (appendix unruptured)	47	23	4.8	26	4.1	6	0
Appendectomy (appendix ruptured)	13		8.1		4.4		0
Unilateral (femoral or popliteal) hernia	3,57	28		79		14	0
Bilateral femoral or inguinal hernia	64		9.7	20			
Excision, testis	5,773	3	0.7	59	1	16	

\*Partial tabulations of entire group of 77,306 cases reviewed

often than after many abdominal operations of lesser magnitude.

In some way unexplained at present, the presence of cancer seems to predispose to thrombosis and embolism. Operations performed on the stomach for malignant conditions are followed by a higher incidence of thrombosis and embolism than are gastric procedures performed for benign lesions. The incidence of fatal pulmonary embolism after exploration alone for malignancy is unusually high and is virtually the same as that for abdominal hysterectomy or splenectomy. The other procedures which most often are followed by fatal pulmonary embolism, it is possible that the poor general condition of the patient, anemia, loss of weight and strength, inanition and other general changes associated with inoperable cancer in this regard are as important as, or even more so than, the actual malignant lesion itself. Thrombosis or embolism may develop among patients with cancer even though no surgical procedure has been performed.

The relative frequency of phlebitis and embolism after pelvic operations has been men-

tioned by many authors. Our experience has been similar. Thus, it is seen that the incidence of embolism and thrombophlebitis is much higher after abdominal hysterectomy than after operations on the gall bladder and bile ducts, both types of operations being done for the most part for benign conditions. The relative magnitude of these procedures is very similar so it becomes apparent again that the site of operation must be a factor of some importance. In pelvic operations there is of course a greater chance of traumatizing veins, both large and small, and perhaps of retarding venous circulation at least temporarily by pressure on the iliac veins. Likewise more veins are ligated in the performance of hysterectomy than in an ordinary operation for disease of the gall bladder.

Splenectomy is followed by the highest incidence of embolism of any surgical procedure (Table I). This is not surprising, however, since when splenectomy is performed the surgeon deals directly with the hematopoietic system and the operation generally is performed in the presence of some type of blood dyscrasia, both of which factors might well

TABLE II—INCIDENCE OF POSTOPERATIVE THROMBOSIS AND EMBOLISM IN RELATION TO AGE IN ABDOMINAL HYSTERECTOMY

Age years	Operations	Thrombosis or embolism	
		Number	Per cent
Less than 20	10	0	—
20-29	168	3	1.8
30-39	1449	42	2.9
40-49	2370	126	4.4
50-59	975	48	4.9
60+	258	11	4.3
Total	5730	230	4.0

contribute to thrombosis. Certain types of blood dyscrasia, of course, have a notoriously high incidence of associated thrombosis.

That infection has some relationship to the postoperative development of thrombosis and embolism is suggested by the fact that both thrombosis and embolism occur with much greater frequency after operation for a ruptured appendix than after removal of an unruptured appendix. Of course, it might be argued that the generally poor condition of the patient in the presence of a ruptured appendix is the main factor, rather than infection. The importance of infection, however, is verified in other ways. Magnitude of the operation, if other factors such as location of the operation, type of lesion, condition of the patient, and so forth are kept constant, appears to be of some significance. Thus, thrombosis and embolism occur approximately twice as often after bilateral inguinal herniorrhaphy as after repair of unilateral hernia.

*Other factors influencing the incidence of thromboembolic phenomena.* It has been observed that the incidence of postoperative thrombophlebitis is higher in women than in men, the ratio being approximately 3:2. In contrast, the occurrence of pulmonary embolism, both fatal and nonfatal, is higher in men than in women. Why thrombosis should occur more often in women and embolism more often in men is not clear. It cannot be explained on the basis of the difference in surgical procedures performed on the two sexes. As is well known, thrombosis and embolism

TABLE III—INCIDENCE OF THROMBOSIS AND EMBOLISM AFTER ABDOMINAL HYSTERECTOMY

Complicating features	Cases	Thrombosis and embolism	
		Number	Per cent
None	3184	62	1.9
Any of following complications	2546	168	6.6
Cardiac disease*	237	17	7.2
Diseases of peripheral veins*	443	25	5.6
Disease of blood*	1241	116	9.3
Carcinoma*	623	29	4.7
Severe infection*	678	39	5.8
All cases	5730	230	4.0

\*Sum of the complicating features will not equal the total number of patients having predisposing conditions because some patients had more than one predisposing condition.

occur relatively seldom in the young patient. This general impression is substantiated by our findings as shown in Table II. It is noted that in a consecutive series of cases in which abdominal hysterectomy was performed, for example, the incidence of thromboembolic phenomena among patients more than 40 years of age was definitely greater than it was among those less than 40 years of age. As age increased beyond this point, there seemed to be no corresponding increase in the incidence of thrombosis or embolism, since the incidence remained between 4 and 5 per cent for all persons more than 40 years old.

In order to evaluate the possible importance of certain definite complicating features predisposing to thrombosis and embolism, it is necessary to consider a single surgical procedure. For this purpose abdominal hysterectomy was chosen (Table III). As seen in this table, there are certain factors which definitely predispose to postoperative thrombosis and embolism. Any disease of the veins, such as varicose veins or residual effects of old thrombophlebitis, increase the chance of development of some form of thromboembolic episode after operation. Likewise, cardiac disease such as chronic valvular lesions, hypertensive heart disease, auricular fibrillation or coronary disease, predisposes to thrombosis or embolism after operation. In fact, it has been observed by Belt of patients who succumb to various medical conditions, with evidence at

TABLE IV.—RELATIONSHIP OF VENOUS THROMBOSIS OR THROMBOPHLEBITIS TO EMBOLISM

Evidence found	Emboli			
	Total		Fatal	
	Number	Per cent	Number	Per cent
Without clinical evidence or evidence at necropsy of venous thrombosis or thrombophlebitis	205	43	33	30
Evidence at necropsy but no clinical evidence of venous thrombosis or thrombophlebitis	165	36	37	5
Clinical evidence alone of venous thrombosis or thrombophlebitis	777			
Total	897	100	243	100

postmortem examination of thrombosis or embolism, that cardiac disease is more prevalent than any other condition. With the additional factor of operation such as hysterectomy it is to be expected that the occurrence of thrombotic or embolic phenomena would be relatively common in this group of patients. Patients who undergo hysterectomy in the presence of diseases of the blood, such as anemia polycythemia vera, leucemia, and thrombocytopenic purpura, have thrombosis or embolism more often than do any other group of patients in which hysterectomy is performed. Many of these conditions, of course even in the absence of operation, predispose to thrombosis and the high incidence of the latter in the presence of these conditions seems to emphasize the possible importance of hematological changes of subclinical degree in the average surgical patient in whom thrombosis or embolism occurs. As mentioned previously malignant lesions and severe infection also make such complications more likely. In addition, it has been observed that obesity is a predisposing factor (38). Other factors which have been considered but which were not found to be significant were the type of anesthesia employed and the season of the year.

*Time of occurrence postoperatively.* It is well known that thrombophlebitis occurs most often during the postoperative period before the patient leaves the hospital. In a recent study of 938 cases in which the clinical diag-

nosis was thrombophlebitis, it was noted that in approximately one-half of the cases the diagnosis had been made between the 9th and the 14th postoperative days (3). In approximately half of the remaining cases the condition occurred prior to this time and in an equal number it was recognized later. It is true of course that in some cases thrombosis may have been present for a variable length of time before it was recognized clinically. It is approximately 10 per cent of these 938 cases there was more than one distinct episode of phlebitis. In two-thirds of the cases in which multiple episodes occurred the interval between the first and last episode (in case more than two occurred) was 1 to 9 days.

A roughly comparable time of occurrence during the postoperative period was noted in the 897 cases of pulmonary embolism, both fatal and nonfatal. In approximately a fourth of all cases of embolism the condition occurred prior to the 7th postoperative day, in a half from the 7th to the 14th day inclusive and in the remainder after 2 weeks.

*Relationship between thrombosis and embolism.* That a relationship between venous thrombosis or thrombophlebitis and embolism exists in many cases seems certain; yet, in other cases there is no recognizable thrombotic phenomenon prior to the sudden appearance of embolism (Table IV). In all the 897 cases of embolism there was no clinical evidence or evidence at necropsy in patients examined in this manner of venous thrombosis or thrombophlebitis in approximately a half of the cases, 45.2 per cent (4). In only a fourth of the cases of embolism was there clinical evidence of venous thrombosis or thrombophlebitis. Of the group in which fatal embolism occurred these conditions were detected clinically in only 4.9 per cent of cases (Table IV). The case in which sudden fatal pulmonary embolism occurs with no antecedent warning is only too well known to all. It seems likely that venous thrombosis may develop and all of the thrombus may become dislodged to form an embolus within so short a period that subsequently even at necropsy no change can be detected in the vein from which it arose. Similarly venous thrombosis, because of lack of reaction in the vein, may cause

ptoms inadequate to be recognized clinically. Thrombosis which occurs in a vein and remains for any appreciable length of time probably results in adherence of the thrombus to the wall of the vein, so that the formation of an embolus from this source is unlikely.

However, it is possible that such a thrombus may suddenly grow proximally, and thereby give rise to a loosely attached clot which might become dislodged and form the source for a pulmonary embolus. This same mechanism probably explains why pulmonary embolism does not occur more frequently after definite thrombophlebitis has been recognized clinically because the thrombus has become adherent. This does not mean that a patient who has thrombophlebitis in one leg, for example, may not subsequently have venous thrombosis in the other leg which may constitute the source for a pulmonary embolus. It was observed that pulmonary embolism occurred in 24.2 per cent of 938 cases in which the clinical diagnosis was thrombophlebitis. In only 4.4 per cent of cases did the embolism appear later than 6 days after the diagnosis of thrombophlebitis had been made.

*Prevention of thrombosis and embolism* Much study and effort has been directed toward the prevention of postoperative thrombosis and embolism, but as yet no completely satisfactory prophylactic measure has been evolved. Many different forms of treatment medication, physical measures, postoperative routines, and so forth have been suggested, but none has proved to be the ideal solution to the problem. Prophylactic treatment has not been effective for various reasons one of which is an incomplete appreciation of the etiology of venous thrombosis or thrombophlebitis and embolism. There appear to be three main etiological possibilities for postoperative venous thrombosis: (1) decrease in the rate of venous blood flow with resultant stasis; (2) trauma or other type of change in the wall of the vein; and (3) some abnormality in the blood itself. It seems likely that the etiology of thrombosis is not represented by a single constant factor, but that often more than one factor is present. In some cases certain factors may be of paramount importance and others of minimal

significance, whereas in other cases the reverse may be true. It has been demonstrated that the rate of venous blood flow is retarded during the postoperative period (27) and that the time of greatest slowing occurs during the interval in which thrombosis and embolism develop most commonly. Almost all investigators agree that venous stasis may be a factor of considerable importance in many cases of thrombosis. In addition, it seems possible that certain abnormal clotting factors which as yet have escaped clinical recognition may be active in certain cases. Local trauma to large veins is associated with the possibility of subsequent thrombosis in the mind of every surgeon and, obviously, is avoided as much as possible.

One of the serious difficulties in the preventive treatment of thrombosis and embolism is our inability to determine before operation in which patient, if he is not treated, thrombosis or embolism will develop after operation. If this could be accomplished the problem of prophylaxis virtually would be solved at present. The fact that such knowledge cannot at present be gained before operation means that any prophylactic measures which are to be successful uniformly must be employed in all surgical cases. This in turn necessitates that any therapy instituted for this purpose be without hazard, of reasonable cost, readily carried out, highly effective, and as foolproof as possible. No such treatment exists today although certain work that now is in progress may bring about a definite advance in this regard. At the present time measures designed to increase the rate of venous blood flow are widely used. These consist of use of the Trendelenburg position, routine exercise of the legs, massage of the legs, application of heat to and elevation of the legs, production of deep respiration by use of carbon dioxide in one of several forms, early postoperative physical activity, medication of one type or another, and various forms of treatment of recognizable venous thrombosis and thrombophlebitis in an effort to prevent extension or new thrombosis and therefore a possible embolus. Experimentally, thyroid extract increases the rate of venous blood flow. As it is employed clinically, however, this may not

always be the case, since the physiological effects of a given dose vary widely in different cases. Of the newer forms of prophylactic treatment heparin has been most effective in the group of cases in which it has been employed for this purpose. Crafoord (10) reported that among 335 patients who underwent major surgical procedures and had received prophylactic heparin therapy during the years 1937 to 1940 thromboembolic complications developed in only 3. This experience is in contrast to that obtained in a group of 302 similar patients operated on during the same years to whom heparin was not administered and among whom thromboembolic phenomena of one type or another developed in 17.5 per cent. Murray and Best (20, 22, 23) have reported similar experiences. Unfortunately in its present form, heparin is not suitable for routine postoperative use. Recently Welch and Faxon have emphasized the value of extraction of venous clots and subsequent venous ligation in the prevention of emboli after the development of venous thrombosis or thrombophlebitis.

*Administration of heparin.* Although heparin was first isolated by McLean in 1916 and later named by Howell and Holt and first employed for the prevention of experimental thrombosis and embolism by Mason in 1924, only during recent years has its clinical use become feasible with isolation of a purified form of heparin which can be administered to patients without the production of toxic manifestations. Charles and Scott, working with Best in Toronto and Jorpes (17) working in Sweden, and Schnitz and Flacher in Germany all working independently produced such a form of heparin. With this new nontoxic heparin available numerous reports of its experimental and clinical use have appeared, especially from Murray, Best and their associates in Toronto (2, 22, 24) and also Crafoord (11, 12) other Scandinavian workers and others (5, 9, 13, 16, 7, 30).

At the present time there are two general methods for the administration of heparin: the method employed largely by the Scandinavians of giving repeated single injections and that used mostly in this country of continuous intravenous administration of it in

physiological solution of sodium chloride or in a 5 per cent solution of glucose. When divided doses are employed, 4 doses are given during the course of 24 hours, 3 of 50 milligrams each during the day and one of 100 milligrams at bedtime or occasionally 3 of 75 milligrams each during the day and one of 125 milligrams in the evening. These are the doses recommended by Crafoord for the Scandinavian product, and he reported most satisfactory results. We have had no experience with this form of treatment although we appreciate that when it is desirable to avoid the intravenous use of fluids this form of administration might be most useful. Work in progress at the present time may develop a method whereby a uniform effect can be exerted by heparin for a period of 24 hours or longer by a single injection.

When heparin is given by means of continued intravenous injection, the physician should endeavor to maintain the venous coagulation time of the blood at a value of from 15 to 20 minutes. There is considerable variation in the amount of heparin necessary to accomplish this purpose in different individuals and also perhaps at different times in the same patient. A starting dosage of approximately 20 milligrams per hour of the Toronto product or an equivalent amount of one of the several available commercial products of heparin usually is satisfactory. This dosage then must be regulated according to requirements of the individual patient. It is essential when heparin is administered by means of continuous intravenous injection that the rate of flow be watched closely and that the coagulation time of the blood be determined as often as necessary (2 to 6 times daily) so that it may be certain that the rate of flow and coagulation time remain within the desired limits. When once started, the administration of heparin should be continued for a minimum of 7 to 10 days or longer if conditions indicate. Repeated periods of administration may be necessary in a few cases. Prompt return of the coagulation time to normal within a matter of several hours follows discontinuance of the administration of heparin. This is greatly hastened by the administration of procaine sulfate, which will



to another episode of embolism. Both of these deaths occurred early in our experience and heparin had been administered for only 2 days, a period which we now know was entirely inadequate. Both deaths occurred after the administration of heparin had been discontinued and the coagulation time had returned to normal. Even so, this figure of 3.2 per cent of embolic deaths due to embolism among patients treated with heparin compares most favorably with a death rate from embolism of 18.3 per cent in members of the untreated group of patients, who had any thing other than an originally fatal single embolus.

In addition to the prevention of death from subsequent emboli, it has been observed that among patients receiving heparin amelioration of clinical symptoms of emboli, such as pain in the thorax, elevation of temperature and increase in pulse rate frequently occurs more rapidly than might be expected otherwise. Not only will the proper use of heparin in most cases prevent subsequent fatal emboli, but it will also obviate further nonfatal emboli in most cases. There have been a few instances in our experience in which further nonfatal emboli occurred some time after discontinuance of the administration of heparin, and in some cases heparin has been given as often as three times, with an interval of perhaps a week or more between each two periods of treatment. Heparin has been employed as a prophylactic measure with completely satisfactory results for a few patients who because of previous phlebitis or embolic phenomena, were considered to be especially likely to experience complications of this type after any surgical procedure. In none of these cases did phlebitis or embolism develop. Almost never has there been evidence of further embolic phenomena during the administration of heparin but in 4 cases a sudden increase in thoracic pain during the administration of heparin has suggested such a possibility.

Unfortunately heparin offers little for the patient who has sudden massive pulmonary embolism which in the ordinary course of events proves to be fatal in a matter of minutes or several hours. Likewise, it will not prevent the pulmonary reaction which is to

be expected in association with the total embolus. If the embolus has been a large one subsequent evidence of pneumonia may develop and in some cases prove to be a serious complication. Bleeding, which ordinarily would not be expected, has occurred in a few cases during the administration of heparin, but in no case has this proved to be a serious factor. In 2 cases there was some bleeding into the wound when the administration of heparin was started soon after operation and when the coagulation time was permitted to become unduly prolonged. In 4 cases hematuria occurred. In all instances bleeding promptly ceased after the administration of heparin had been discontinued. It is apparent that heparin does not offer the ideal solution to the problem of postoperative embolism, although it is possible that certain improvements in its use may enhance its value in the future. Recently another anticoagulant, 3,3-methylene-bis-(4-hydroxycoumarin), has been suggested, and work with this product is now in progress (7). It is possible that this may largely supplant heparin as an anticoagulant in the prevention and treatment of thrombophlebitis and embolism.

Our experience with the use of heparin in the treatment of thrombophlebitis has been more limited and less definite than in embolism. There is so much variation in the clinical course of thrombophlebitis, depending on its location, site, extent of infection present and general condition of the patient, that definite criteria in a group of control cases are not readily obtained. It is our impression, however, that heparin will prevent further growth of a thrombus and in this manner prevent aggravation of the condition. Furthermore, it prevents other thrombi from developing during the course of its administration. In addition to the suggestions of the use of heparin and the conventional treatment of immobilization, elevation, and heat, other suggestions have been made during recent years for the treatment of thrombophlebitis and favorable results have been reported. These include paravertebral injection, as it has been stressed by Ochsoer and DeBakey and venous ligation, as suggested by Welch and Faxon.

# SUMMARY

Pulmonary embolism in our experience is responsible for approximately 6 per cent of deaths which occur after major surgical procedures. A number of factors influence the likelihood that embolus or thrombosis will follow any operation, and these include site of the operation, magnitude of the procedure, presence of infection or malignancy, diseases of the blood or cardiovascular system, obesity, age, and sex. The majority of all thrombo-embolic phenomena occur within the first 2 weeks after operation. Approximately 1 in 4 cases of pulmonary embolism is associated with clinical evidence of thrombophlebitis, and similarly, approximately 1 in 4 cases of thrombophlebitis is associated with evidence of embolism. Of all patients who experience pulmonary emboli, approximately one-half have a single nonfatal embolus, one-quarter have a single fatal embolus, and the one-quarter remaining have multiple emboli which in approximately 60 per cent of cases are followed, finally, by fatal embolism. Proper use of heparin in all cases in which evidence of nonfatal pulmonary embolism is available should prevent about one-third of the deaths which now occur from postoperative pulmonary embolism.

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## CYTOLOGICAL FACTORS IN PERITONITIS AND PERITONEAL IMMUNITY

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PERITONITIS continues to offer the greatest hazard as a complication of intra-abdominal surgery and intra-abdominal inflammatory processes. This fact no doubt has provided the incentive for the vast amount of experimental and clinical investigation which has been carried out in an attempt to combat this common pathological process.

Reports of experimental work on peritoneal immunity extend back to the work of Isaacff in 1894 but it is only since about 1927 that extensive experimental and clinical studies have been made. Goldblatt and Steinberg found that small repeated intraperitoneal injections of a culture of *Bacillus coli* would produce immunity against a subsequent lethal intraperitoneal injection of the same organism. Herrmann produced similar findings with a killed mixed culture of the *Streptococcus viridans* and the colon bacillus. Both of these experimental results have found clinical application (8, 13, 14).

These findings were highly suggestive that this locally induced immunity was specific in character. In an attempt to produce peritoneal immunity experimentally with specific bacterial filtrates (anti-frus) it was discovered that nonspecific innocuous substances as glucose solution would work equally as well (7). It was also noted that the element of time was a factor in the development of an adequate defense against definitely lethal intraperitoneal inoculations. This local peritoneal immunity was dependent upon or associated with the presence of an increased number of macrophage cells. Suggestive evidence was presented that these cells originate from the endothelial cells of the omentum.

Since my report of this work, other investigators have made similar findings, both clinically and experimentally. Several writers have expressed the belief that local peritoneal immunity is non specific in type regardless of

the activating agent, and some have stated that nonspecific substances work equally as well if not better in producing such an immunity. In comparing mixed vaccine (Rangen) sodium ricinoleate and amniotic fluid concentrate Seeley, Higgins and Mann found the greatest response by the mononuclears was produced by sodium ricinoleate about 72 hours after its peritoneal injection, and the next greatest response was by amniotic fluid concentrate after 168 hours. Corwin found the true quantitative cellular response to the intraperitoneal injection of sodium ricinoleate to be nearly twice that to Rangen's vaccine (Intraperitoneal). He concluded that any of a large number of so called specific or nonspecific substances should prove equally effective in producing a local peritoneal immunity that 1 to 3 days before operation seemed the optimum time for the injection and that the induced immunity was dependent upon the presence of histiocytes.

Rixford found at varying intervals after the intraperitoneal injection of vaccine (Rangen) in man that the total cell count and the percentage of polymorphonuclear cells are greatly increased but that the smoothness of the convalescence was proportional to the total number of histiocytes present.

With the use of the sulfonamide group of drugs in the local treatment of infection application has been made to the peritoneum by Throckmorton found experimentally that the cellular responses elicited by these various compounds were qualitatively those of non specific peritoneal irritation. The qualitative differences seemed due to variation in solubility and irritation rather than specific cellular stimulation. Of the various drugs studied sulfathiazole seemed best suited as a stimulant of peritoneal defense. In an excellent detailed discussion of the literature and his own experimental and clinical findings on the various methods of preventing a



Fig 1



Fig 2



Fig 3

Fig 1 Photomicrograph of a section of normal omentum (low power)

Fig 2 Photomicrograph of a section of omentum from patient 48 hours after the intraperitoneal injection of amfetin (low power)

Fig 3 Photomicrograph of section of the omentum from the same patient as that shown in Figure 2, but removed 3 weeks later. In this specimen is observed normal cytology except for the presence of fibroblasts at the margin (low power)

treating peritonitis, Rea states that his results obtained with the sulfonamides were impressive but questionably better than those obtained with other substances when used prophylactically.

Surgeons have recognized for years the importance played by the great omentum in combatting intra-abdominal inflammatory processes. That the omentum will migrate to an area of inflammation and attempt to keep it localized by walling it off is common knowledge. The other defensive responses on the part of the omentum are not generally known. Experimentally it has been shown that there is a definite cellular response in the omentum to intra-abdominal invasion by bacteria (7).

It is my purpose at this time to describe the response of the omental tissue of man to intraperitoneal infection or irritation. Recently I have studied stained sections of omenta from patients who have had preoperative intraperitoneal injections and from patients in whom acute or subacute intra-abdominal inflammatory reaction was found at operation. In this study the intraperitoneal injections were made with amniotic fluid concentrate (amfetin) 48 hours prior to colon surgery. The cases of intra-abdominal inflammatory disease were divided between acute appendicitis, subacute cholecystitis, subacute salpingitis, ruptured ectopic pregnancy, and evisceration of abdominal contents.

These omenta on gross inspection vary in color from slight pinkish tint to light red color and are a common finding in an acute or subacute abdominal condition. On microscopic section these omenta show dilatation and engorgement of the capillaries commensurate with the amount of inflammatory reaction as evidenced by color. Around the capillaries and in the connective tissue meshwork are varying numbers and proportions of polymorphonuclear leucocytes and mononuclear cells. This number and proportion vary with the severity and duration of the intraperitoneal irritation. In the cases in which the infection or irritation has been of short duration, the predominant cell is found to be the polymorphonuclear neutrophile. Where the process is of longer duration, there is a shift in favor of the monocytes. No attempt has been made to classify these monocytes but, following the usage of Witts, the term macrophage might well be used to include all cells which have been variously designated as histiocyte, clasmatocyte, etc.

All writers on the subject of peritoneal immunity seem to agree on the point that this defense is dependent upon a local leucocytosis (12), but opinion seems divided as to the relative importance of the polymorphonuclear cell and the mononuclear cell in the defense mechanism. A fairly constant finding in favor of the monocyte as the more impor-



Fig. 4

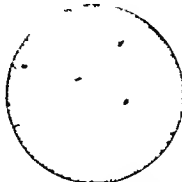


Fig. 5



Fig. 6

Fig. 4. Photomicrograph of section of omentum in acute appendicitis, early showing moderate diffuse infiltration of cells, mostly polymorphonuclear leucocytes (low power).

Fig. 5. Photomicrograph of smear of peritoneal fluid in case of appendicitis about 24 hours after onset, showing

occasional polymorphonuclear leucocytes (low power).

Fig. 6. Photomicrograph of section of omentum from same case shown in Figure 3, showing heavy concentration of cells around the capillaries, about 90 per cent of which are monocytes (low power).

tant cell in peritoneal defense is the corresponding interval of time required for establishment of immunity and mobilization of the macrophage cells. This latter type of cell has also been shown to possess greater phagocytic power. It has also been shown experimentally that the presence of enormous numbers of polymorphonuclear leucocytes alone will not successfully combat extensive intraperitoneal infection (7).

Intraperitoneal immunity is always a variable quantity, and its adequacy in protecting the organism against the invasion of pathogenic organisms will be determined in any given case by balancing the strength of the local defense mechanism against the magnitude of the invading infection. Barger states that his method of preoperative intraperitoneal vaccination will not always prevent peritonitis where gross soiling occurs but it does help to mobilize the defensive forces. Even when the defensive forces respond to an appreciable extent they may still prove inadequate to overcome a massive infection.

The mode of entry of the macrophage cells into the peritoneal cavity offers an interesting speculative study. In the omentum they are seen grouped around and in very close proximity to the capillaries. This same observation has been made in sections of peritoneum from immunized animals (7). In clinical cases of acute suppurative appendicitis, it is

possible to find a perivascular grouping of cells in the omentum before they appear in increased numbers in the peritoneal fluid as will be shown later. The work of Higgins and Bain suggests the possibility of lymphatic or similar channels adjacent to the capillaries of the omentum. Since histiocytes are seen first to increase in these areas, it is quite possible that they have their origin from these perivascular areas the cells of which may belong to the reticuloendothelial system.

The great omentum from an abdomen free of infection or irritation is quite acellular and is composed of loose areolar meshwork containing blood vessels and adipose tissue (Fig. 1). Forty-eight hours after the intraperitoneal injection of 50 cubic centimeters of amniotic fluid concentrate there is a definite engorgement of the capillaries of the omentum and a marked increase in the cellular content, a large percentage of which is monocyte (Fig. 2). The omentum of this same patient studied 3 weeks later without preoperative injection again appeared normal except for fibroblastic changes at the margin (Fig. 3).

The developmental cytological changes associated with developing intraperitoneal irritation or infection can best be followed in cases of appendicitis in different stages or periods of development. In the earliest stages of acute appendicitis, there may be no detectable increase in intraperitoneal fluid and



Fig 7



Fig 8

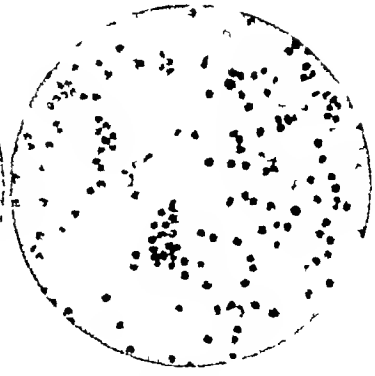


Fig 9

Fig 7 Photomicrograph of smear of peritoneal fluid in a case of peritonitis 36 hours after onset Appendix gangrenous but not perforated Heavy concentration of cells, a large percentage of which are monocytes (low power)

Fig 8 Photomicrograph of section of the omentum from a case of ruptured appendix This specimen shows

a moderate infiltration of cells all of which are monocytes (low power)

Fig 9 Photomicrograph of smear of peritoneal fluid from same case as shown in Figure 8, shows moderate concentration of cells the majority of which are polymorphonuclear leucocytes (high power)

without increase in cellular content, but there may be an increase in the cellular content of the omentum At this early stage a large percentage of the cells are found to be polymorphonuclear neutrophils (Fig 4) In a more acute involvement of the appendix about 24 hours after the onset of symptoms, a definite increase in thin amber peritoneal fluid has been found which contained only an occasional polymorphonuclear leucocyte and no monocytes (Fig 5) The omentum of this same case showed a heavy concentration of cells, about 90 per cent of which were monocytes, arranged mostly around the capillaries (Fig 6) When a case has become more advanced after a period of about 36 hours but before perforation has occurred, the cellular pattern of the omentum may contain a heavier infiltration of monocytes, but at this stage of development the peritoneal fluid will usually contain a heavy infiltration of cells, a large percentage of which may be monocytes (Fig 7)

This apparently is the defense mechanism which nature sends out in advance of an impending bacterial invasion For we have similar findings in a case of a ruptured appendix with generalized peritonitis about 40 hours after the onset of symptoms A moderate infiltration of cells, all of which were monocytes was seen in the omentum (Fig 8) In this case a majority of the moderate number

of cells in the peritoneal fluid was found to be polymorphonuclear neutrophils (Fig 9) No bacteria were found in the fluid (Fig 10) The clinical course was stormy but satisfactory with no doubt a gradual increase in the number and percentage of the macrophage cells These last 2 cases demonstrate the individual variation in the development of a local peritoneal immunity and that there is a definite quantitative factor in its production

#### EVALUATION

There are very definite clinical deductions which can now be made from these findings The cellular defense mechanism is apparently



Fig 10 Photomicrograph of same smear as shown in Figure 9 (oil immersion) showing detail of a group of macrophage cells

set into motion by any irritation or foreign substance within the peritoneal cavity. A markedly inflamed intra-abdominal organ may be the exciting factor in calling out the defense forces against any possible subsequent infection. In generalized peritonitis, the diffuse presence of the infection and inflammatory exudate is as great a stimulus to the defense mechanism as any other foreign agent would be. For this reason there is no scientific background for the use of various substances intraperitoneally in the presence of generalized peritonitis for the purpose of increasing peritoneal defense. This is in conformity with the clinical observations of Rea. He has noted however very definite clinical value in the use of sulfonamides intraperitoneally in what he terms the pre-peritonitis phase of a local intraperitoneal infection or soiling.

On the basis of our present knowledge of peritoneal immunity our treatment must at least in a sense be prophylactic. The use of vaccines, sulfonamides, and other substances at the time of local soiling or contamination has a rational basis, as these substances may set up a defense reaction before the infection has time to increase and spread. It is this increase in defense mechanism ahead of the infection which can be considered of real value.

It must be admitted that the ideal substance or method for inducing peritoneal immunity has not been found. It has been described as one which is innocuous, free from side reactions, has a short immunizing period and produces immunity similar to that developed by the normal peritoneal cavity against infection (9). From an analysis of the present facts it is apparent that all of these can be fulfilled except the element of time which is involved in producing an immunity which is adequate against an infection of any magnitude.

It has been possible to produce such an immunity in animals, but it requires 2 to 4 days' time and the possibility of repeated injections (7).

This is possible in preoperative preparation only. To combat a spreading infection from soiling at operation or from a perforated viscus the best substance at the present time

seems to be sulfathiazole. It is probably bacteriostatic in addition to being an extender of local peritoneal defense and is absorbed quite slowly. The ideal substance in treating peritonitis either generalized or local, must well be a rapidly acting germicide with low irritability, great diffusibility, slow rate of absorption and be unaltered by exudate or moderate dilution. Such a substance would also provide adequate stimulation to the cellular defense mechanism.

In cases of intraperitoneal infection with varying amounts of increased intraperitoneal fluid it is quite general practice for surgeons to aspirate this fluid. From the promised studies of this fluid, the rationale of the procedure as a routine practice might well be questioned. It might be suggested that a study of this fluid by means of stained smear at operation would yield information which would influence one in the proper disposition of this fluid and the proper management of the peritoneal cavity. Soon after the perforation of a heavily infected viscus as the colon if the peritoneal fluid showed a low cell count and high bacterial count, aspiration of any fluid or foreign material and irrigation of the peritoneal cavity either locally or generally as indicated might be a valuable procedure. On the other hand if a smear showed the balance of power to be in favor of the cellular elements, then harm would most certainly result from the generally condemned procedure of irrigating the peritoneal cavity or from aspirating the fluid present.

#### SUMMARY

Previous studies have shown that peritoneal immunity is dependent upon, or at least associated with, the presence of large mononuclear (macrophage) cells in the peritoneal fluid.

2. Findings are now presented which show that these cells also appear in the omentum of patients with peritonitis or who are immunized against intraperitoneal infection.

3. Evidence is presented to show that these cells appear in the omentum before they appear in the peritoneal fluid and that their appearance is preceded by the polymorphonuclear leucocyte.

# MORTON CYTOLOGICAL FACTORS IN PERITONITIS

- 4 There is suggestive evidence that these mononuclear cells originate from the perivascular spaces of the omentum
- 5 A definite time factor is involved in the development of peritoneal immunity
- 6 An attempt is made to establish a rational basis for the use of certain drugs and procedures in the prevention and treatment of peritonitis

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# SECTION OF THE POSTERIOR ROOTS FOR THE RELIEF OF PAIN IN ANGINA PECTORIS

## Observations in Five Cases

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FROM its earliest beginning the practice of medicine has been dedicated to the relief of human pain and suffering. The pain of most diseases is controlled by drugs and finally relieved by a restoration of the bodily functions to normal. Unfortunately we, as physicians, are faced with certain clinical entities in which pain may be an intractable manifestation, often uncontrollable by medical treatment, and the morbid process such as to preclude a restoration of the bodily economy. Angina pectoris may take its place in this group along with trigeminal neuralgia, inoperable cancers, and tabetic crises. Varied surgical methods have been suggested for relieving the pain in these and similar conditions. They have often been charged with empiricism. However the record of experimental work upon the physiology of pain, a voluminous literature compiled by many investigators, is at long last leading us to more logical and more certain methods for the relief of these painful states.

Here it is our purpose to review briefly the physiological basis for a surgical operation aimed at relieving the pain of angina pectoris and to report the results in 5 patients treated by this method, together with a discussion of the indications for and against its use.

Francois Frank is generally credited with being the first to suggest that severance of cervical sympathetic fibers transmitting painful impulses from the heart to the central nervous system would stop anginal pain. It remained for Jonnesco 17 years later to put the idea to the test and demonstrate the feasibility of surgical methods for the relief of this agonizing pain. Many surgeons followed his example and thereafter various

types of operations were performed upon the cervical and cervicodorsal sympathetic system. High mortality rates, unpleasant post-operative complications, and failure in many instances to effect complete relief were deterrents to more widespread popularity of the method (3 6 8 16 8).

In 1923 Danielopolu and Hirstide proposed, but did not do, resection of the posterior roots in the lower cervical and upper dorsal region. Their proposal was based upon the theory that cardioaortic pain was always referred, hence denervation of the area of reference would relieve the pain. Also, they pointed out that such a procedure would not interfere with important centrifugal fibers. Swisher further focused our attention upon the sensory pathways and introduced paravertebral alcohol block for the treatment of cardiac pain. He hypothesized that "constant stimulation of the small cells in the dorsal root ganglia by impulses coming from the heart is referred to the skin segments supplied by the respective ganglia, which in turn refer this irritation to the consciousness as pain." Cotler in a critical review of the surgical treatment of angina pectoris up to 1927 cited the temporary nature of the relief obtained from the injection treatment and warned against "surgery unaided by vision and the use of a powerful drug like alcohol particularly when in proximity to the delicate structures of the nervous system."

Further clinical and experimental studies by White Sutton and Lueth, Davis and Pollock, Anrep and Segal, Ranson, and Kuntz have served to show that visceral pain is mediated by afferent efferents of the somatic system which traverse the sympathetic trunk. Their cells of origin are in the posterior root ganglia. From the heart these fibers reach the cord by way of the upper four or five dorsal

roots bilaterally and, as White expressed it, 'this is the neck of the bottle'—all the sensory fibers entering the spinal cord from the heart are here nicely grouped and vulnerable to direct attack. These workers have also shown that the sympathetic system provides the vasodilator mechanism to the coronary vessels while the vagus or parasympathetic fibers are chiefly vasoconstrictor in their actions. Thus it appears probable that contrary to the hopes of some, procedures aimed at the removal of the sympathetics not only interrupt the cardiac afferents but to some extent, interfere with the normal vasodilator mechanism of the coronary circulation or it is perhaps safely said that such procedures do not specifically interrupt vasoconstrictor impulses to the heart.

In the light of present knowledge then the logical plan would be directed at interruption of the cardiac afferent fibers with as little disturbance as possible of important centrifugal mechanisms. Section of the afferent rami communicantes or the posterior roots of the first five thoracic segments should effectively achieve this aim. The former method entails an operation on both sides, each of which is almost as grave as the single procedure necessary to section the posterior roots bilaterally. Paravertebral alcohol block interrupting the sensory pathways at the level of the former procedure is perhaps not without effect upon the centrifugal pathways. This method meets with failure about one fourth of the time (19, 20), and, in addition, although it has recently been controlled to some extent by the use of vitamin B, the resultant neuritis has been a troublesome complication in a number of our patients. We have been inclined to believe with Cutler that direct vision methods produce more reliable results.

As for the operation directed at section of the thoracic posterior roots, we believe that there now can be little question of its logic or the results achieved. As previously mentioned, it was suggested by Danielopolu in 1923. Ranson noted that in 1926 Sachs had cut the sensory roots of the first four thoracic nerves on the left side and thus obtained relief in a case in which characteristic anginal pain had recurred after removal of the cervical sympa-

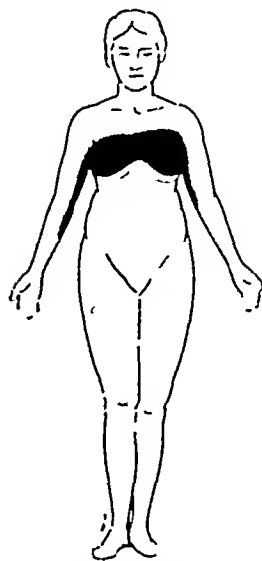


Fig. 1. Diagram of the sensory loss following operation in Case 1. The stippled area in the thigh is the hyperesthetic zone mentioned in the text.

thetic ganglion. Davis is to be credited with being the first to carry out successfully the operation of bilateral posterior root section in a case of angina pectoris. Cone is also reported to have performed this operation in two cases (19, 20).

There has been some criticism of many of the reports in the literature on the surgical treatment of angina pectoris (4, 5), and Boas stresses the necessity of differentiating between various types of cardiac pain and true angina pectoris. Also, many authors have felt that the pain of angina pectoris is a warning to the individual to slow up and that the removal of this danger signal is unwholesome.

Naturally radical measures such as alcohol injection or operation should be used only in those obstinate cases in which the pain persists in spite of ample medical measures and is of such a degree as to render work impossible and life miserable. The selection of cases is, therefore, most important and should be limited to those patients having intractable anginal syndromes. The following cases, we believe, meet these requirements and permit a fair evaluation of the method, a clinical verification of some of the experimental work upon which the procedure is based, and some



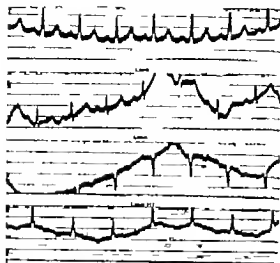


Fig. 2a

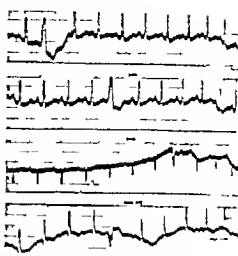


Fig. 2b

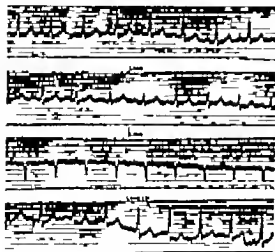


Fig. 2c

Fig. 2. Electrocardiograms in Case 1. a, August 4, 1936, before operation; b, September 8, 1936, the first postoperative day; c, March 14, 1941, 4 1/2 years after operation. Note changes in chest leads referred to in the text.

observations upon the reference of anginal pain.

CASE 5085. Hypertensive and arteriosclerotic heart disease with previous coronary thrombosis resulting in angina pectoris: pain not controlled by bed rest and excessive opiates; section of upper thoracic posterior roots; patient converted from bed-ridden in adult to person of almost normal activity for her age.

Mrs. E. M. age 55 years, the wife of a retired realtor was first seen on August 4, 1936. Her

mother and grandmother had died of heart disease. She had had no pregnancies and, except for appendectomy in 1908, had always been well until September 1933, when she contracted pneumonia from which she completely recovered in 3 to 4 weeks.

In December 1933, while eating breakfast, she was suddenly seized with sharp substernal pain which was accompanied by a sense of impending disaster causing her to "freeze and quiver" in her chair. She was immediately hospitalized and remained in bed for the next 5 months, during that period she required many hypodermic injections for control of her pain, which continued to recur at intervals of 1 to 2 days. The pain radiated to the left arm and, when quite severe, was also noticeable in the right thigh. She was up and about in May 1934 but continued to have attacks of pain necessitating narcotics hypodermically at intervals of 1 or 2 days. On several occasions, the anginal attacks caused her to collapse in the street. She became unable to do the laundry in her bedroom so an elevator was installed in the house for her convenience. Finally, even the ride in this seemed to precipitate an attack. In May 1936, sympathetic injection was contemplated at another clinic, but it was discouraged because of the seeming severity of her condition. From then on, increasing doses of narcotics were given to make her comfortable. For some time she had remained at home receiving 1/6 grain dilaudid every 4 hours. There was some question of adding morphine to the dilaudid, but she continued having attacks at the slightest exertion coupled with moving herself about in bed and she voiced a sincere desire to be rid of the necessity of taking dope.

**Examination.** The patient was a slightly hypertensive well-nourished woman, 64 inches tall, weighing 133 pounds. She appeared older than her stated age of 55. There was some hypertrophy of the skin over the left breast and precordium in pro-

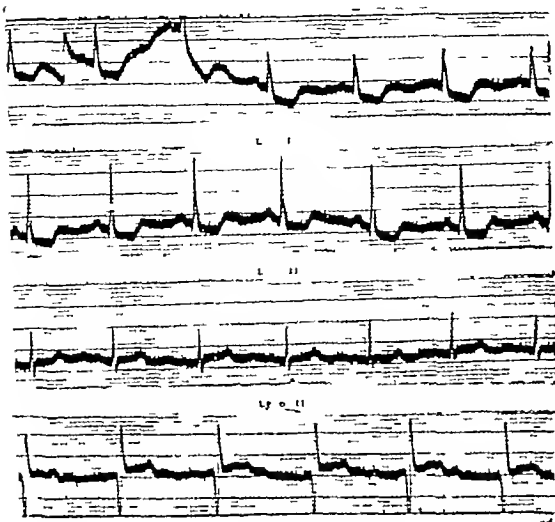


Fig 3a

eral No cardiac murmurs were audible, and the heart rate was 76 with an occasional extrasystole. The blood pressure was 190/88, the temperature 97.6 degrees F.

Laboratory studies revealed that the blood and urine were normal. The blood Kolmer and Kahn tests were negative. X-ray studies of the gastrointestinal tract and gall bladder revealed no pathological condition. A teleroentgenogram revealed the heart to be of normal size and contour. The lung fields were clear. Venous pressure was 110 millimeters of water. The vital capacity was 2.3 liters. An electrocardiogram showed a rate of 96 and a P-R interval of 0.2 of a second, there was a tendency toward left axis deviation,  $Q_4$  was absent (original technique of Wolfarth and Wood)<sup>1</sup>,  $T_3$  was inverted,  $T_4$  was isoelectric, and  $T_1$  and  $T_2$  were upright. These findings were regarded as probably indicative of previous cardiac infarction.

Observation of this patient from August 14 until September 17, 1936, showed that satisfactory relief could not be obtained by the use of many varied vasodilating substances. Only ever increasing doses of opiates were successful in alleviating the pain. On one occasion, when a severe attack was in progress and the complaint of pain in the right thigh was particularly distressing, the subcutaneous tissues of the area of reference in the thigh were infiltrated with 1 per cent novocain. This relieved the pain in that area, but the attack continued unabated in the chest and left arm. There was some fear that there might

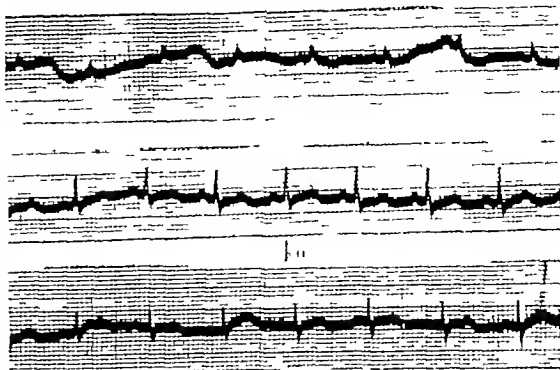


Fig 3b

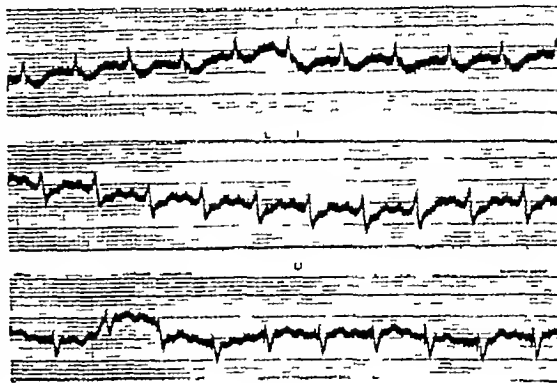


Fig 3c

Fig 3. Electrocardiograms in Case 2: a, February 16, 1937, before operation; b, March 6, 1937, the first postoperative day; c, March 8, 1937, third postoperative day with evidences of new cardiac infarction.

be a major functional element in this patient's complaints, but after long study we were convinced that these attacks were cardiac in origin and truly anginal in character and that surgical therapy was justified.

Operation was performed on September 17, 1936. Basal anesthesia of avertin, 100 milligrams per kilogram, was given at 8:50 a.m. Local infiltration of the skin and muscles with 1 per cent novocain followed, and a laminectomy with removal of the spines and laminae of the first four dorsal vertebrae was done. The dura was opened, and the first, second, third, and fourth thoracic posterior roots on the right side were severed. On the left, the first, second, third, fourth, and fifth thoracic posterior roots were cut. The dura was closed with interrupted silk sutures, and the muscles, fascia, and skin approximated in the usual manner without drainage. There had been no appreciable change in the blood pressure throughout the operative procedure, and, while cotton pledgets moistened with novocain had been placed over the individual roots previous to their being handled, this did not serve as sufficient analgesia,

<sup>1</sup>In our laboratory from 1933 to January 1, 1938, the technique employed for taking chest leads was as follows: The right arm wire was attached to an electrode 3 centimeters in diameter which was placed over the apex cordis. The left arm electrode was placed between the midline of the back and the angle of the left scapula. Subsequent to January 1, 1938, all chest leads were made according to the recommendations of the Committee for the Standardization of Precordial Leads. Lead  $V_1 F$  has been employed for general use.



Fig. 4. The new myocardial infarct in Case

a d few lifts of ether were necessary during this part of the procedure. The patient was awake and co-operative upon completion of the operation. She frankly stated that she really felt better than at the start.

*Successful course.* This patient made an uneventful and uncomplicated recovery. She did not request any sedative following operation. Her only complaint of discomfort was an occasional dull headache below the area of operation. For 3 days following operation her pulse rate varied between 30 and 40. An electrocardiogram revealed this to be sinus bradycardia (rate 30) without other significant differences from the previous tracing. On the 4th postoperative day the pulse rate returned to below 60. She was discharged from the hospital on the 8th postoperative day, walking and free from pain.

She returned on November 6, 1936, for observation. She appeared to be in good general condition, had had no anginal attacks, and was, except for her leading rather normal existence with only slightly limited activity. Neurological examination at that time revealed only the sensory loss over the areas subserved by the sectioned dorsal roots. It had the typical pattern of root lesion at its borders. A electrocardiogram then showed a rate of 60 and otherwise the same findings were noted before.

On March 4, 1937 this patient responded to our request that he come to Seattle for check-up. At this time he reported that she had been generally well and had consulted no physician since her last visit to the clinic. She had taken no medicines or drugs except an occasional laxative. There was some fatigue at the end of the day and, after the exertion of climbing a number of stairs she had some dyspnea but no pain. There were some paresthesias noticed at times in the denervated areas the borders of which were unchanged from 1936. Since her operation she had engaged in the usual activities of her social group without apparent limit. He had made four thousand mile motor trip with her

husband and had gone through a week of 100 to 110 degree temperatures in the southern states with no more than average trouble.

Clinical examination at this time showed the left border of cardiac dullness to be at the midhumeral line. Heart sounds were of fair quality with a murmur barely audible over the mitral area. The pulmonary and aortic second sounds were equal. The blood pressure was 120, 120. The extremities showed no edema, and the liver was not palpable. Laboratory studies of the blood and urine were within normal limits. The venous pressure was 92 mm. Hg, respiratory capacity 1.7 liters. The circulation rate with calcium gl. conat and ether as arm to femur 3 seconds 100 to 120 seconds. A thormer genogram showed a heart of normal size and contour. The lung fields were clear. A electrocardiogram showed a rate of 68, P-R interval of 0.14 second, sinus rhythm, and tendency toward left axis deviation, the T wave lead I/F as upright which corresponded with the inverted T of the technique of the 1936 tracing. As normal T<sub>1</sub> finding is noteworthy in that the corresponded T<sub>1</sub> as absent in the 1936 tracings obtained by the earlier technique.

*CASE No. 4806.* Arteriosclerotic heart disease with angina pectoris of seven years duration, previous coronary thrombosis, pain unrelieved by rest or medical means, operation followed in relief of pain, death fourteen hours after coronary occlusion causing massive cardiac infarction, unaccompanied by pain, autopsy.

Mrs. H. P., aged 53 years, the wife of a farmer, as first seen on July 5, 1933. Both her parents had died of the infirmities of age. There was no family history of cardiac or renal disease. One tube and her appendix had been removed in 1921 and tonsillectomy was performed in 1920. She had suffered from arthritis at various times for about 25 years. At that time she complained of pain which radiated down the inner aspects of both arms from the shoulders to the hands. This was precipitated and aggravated by exertion. It seemed to be associated with other arthritic manifestations, and there were no special symptoms referable to the heart. Her blood pressure was 90/85, her pulse 50 and regular and her heart tones normal. Both lungs transilluminated poorly and were clouded on examination. They were dilated and irrigated. In August, 1933 she reported that she was much improved but on exertion could occasionally suffer pain beginning in the left arm radiating upward and across the chest to the precordial region, etc., as not seen previously. February 6, 1937, when she was admitted to the hospital complaining of pain on the inner aspect of the right arm on the slightest exertion. She then stated that these pains had been present intermittently 7 years before. The pain on the left side had been relieved with the administration of morphine. The pains were always precipitated by exertion and relieved by rest. At times there was radiation of the pain to the eye

gastrum and an associated shortness of breath. There had been a constant increase in the frequency and severity of the attacks. Considerable medical treatment, administered by several different physicians, had been ineffective. She had suffered intense pain since the evening before, and, on admission, the slightest movement of her body caused an increase of the pain. For some period of time, any undue excitement or even the slight exertion of making a bed, had been sufficient to precipitate an attack.

*Examination* The patient's development and nourishment were normal. She weighed 123 pounds. Her lungs were normal to auscultation and percussion. The heart borders were indeterminate. A systolic murmur was heard at the apex. The blood pressure was 120/80. The pulse rate was 75. Urinalysis, blood counts, and serology were normal. X-ray film of right shoulder showed no arthritis. A cholecystogram was normal. Teleoroentgenogram of the chest showed clear lung fields, and a cardiac shadow which was within normal limits. The venous pressure was 90 millimeters, and the vital capacity, 2.3 liters. An electrocardiogram showed a rate of 72, a *P-R* interval of .18 seconds, and positive *T*<sub>4</sub> and depressed *S-T* interval in leads I and II, which was suggestive of digitalis effect.

The patient was seen by a number of our internists, and the conclusions at this time were that she had arteriosclerotic heart disease and angina pectoris. The interesting feature of a right sided angina was noted. While at rest in the hospital, she continued to have pain. Occasionally, nitroglycerine afforded temporary relief, but frequent recourse to narcotics was necessary to control the anginal attacks which would, at times, come spontaneously or be precipitated by the effort required to turn while her bed was being made up. After more than 2 weeks in the hospital, all medical measures seemed doomed to failure, and the patient requested more certain relief.

Operation was performed March 5, 1937. Preliminary medication of morphine sulfate,  $\frac{1}{4}$  grain, and atropine,  $\frac{1}{150}$  grain, was followed by a basal anesthesia of avertin, 100 milligrams per kilogram. One per cent novocain was infiltrated in the subcutaneous tissue and muscles, and a laminectomy of the first four dorsal segments was performed. The dura was opened, and the first five thoracic posterior roots were secured on each side and cut between Cushing clips. There was slight oozing of blood from the dura near the exit zone of the third root on the right, which was easily controlled with a small muscle stamp. The dura was sutured with interrupted silk, and the wound was closed without drainage in the usual manner. The blood pressure, which had been 120/80 previous to operation, fell to 80/60 at the beginning of the operation but, with the stimulus of surgery, rapidly regained a satisfactory level, about 115/70, where it remained until her return to the ward in seemingly good condition at the close of the operative procedure.

*Subsequent course* This patient's immediate reaction following the operation was satisfactory. The first 2 days following operation, she was exceptionally comfortable, suffered none of her old pain, and moved about in bed freely without precipitating any attacks. Her blood pressure varied from 90/50 to 120/80, and on the second postoperative day she felt so well, she decided to do without her special nurses. On March 6, an electrocardiogram was made. It showed the rate to be 96. The *P-R* interval was .18 of a second. There was less depression of the *S-T* interval in lead I, and no depression in lead II as compared with the tracing made on February 16. The patient had not received any digitalis in the interval. There was no evidence of cardiac infarction. Early in the morning of March 8, the third postoperative day, she suddenly complained of a peculiar feeling of tightness across the chest which, she insisted, was not painful. She became nauseated and vomited. A little later, she felt as though she were short of breath, but she could inhale deeply, etc., without difficulty and her respiratory rate was not increased. Her blood pressure suddenly dropped to 60/7. Her pulse had jumped from 90 to 130 and was weak and irregular. Her temperature was not elevated. Her venous pressure had risen to 98 millimeters. An electrocardiogram showed a rate of 120, a *P-R* interval of .18 of a second. The *S-T* intervals in leads I and II were depressed, aberration of *QRS* was marked, and there was a lowering of potential in all leads. When compared with the tracing of March 6, it was considered that an acute cardiac infarction had occurred. In spite of the oxygen and cardiac stimulants, she succumbed about 14 hours after the apparent acute inception of this latest coronary episode. To the last, she was seemingly clear mentally and most co-operative. She insisted at all times that she had no pain but a certain knowledge that something was wrong in her chest. This she variously described as a peculiar sense of tightness, a feeling of pressure over the precordium, or a feeling as though she could not get her breath although, at the same time, she realized that she was breathing regularly and at a normal rate.

*Postmortem examination* The body had been embalmed shortly after death, and the autopsy was performed 2 hours later. Marked adhesions of the abdominal viscera resultant from the ancient laparotomy were found. There was also pulmonary edema and acute passive hyperemia of the liver and spleen. The heart weighed approximately 400 grams. Practically all the interventricular septum and the wall of the left ventricle appeared to be involved in a fresh process of infarction. The valves and cusps of the heart were free of gross alterations. The coronary vessels were markedly sclerotic. The descending branch of the left coronary was practically obliterated by calcareous deposits in the wall of the vessel. Near its point of origin, it was completely occluded by a red purple thrombus. All the coronary vessels were brittle and, in cutting across them

with the knife sensation of stone like hardness as detected. The lining of the uterus as approximately 5 per cent changed to yellowtherosclerotic plaques.

Case 3. A gynecological attack of 33 in duration para-vertebral alcohol block on the left followed by temporary relief recurrence of symptoms posterior root section with return to employment.

Mrs. H. S. aged 39 years, who was married 15 years and graduated nurse was first seen in November 1937 when she was referred to the Clinic by a local internist for para-vertebral alcohol block. She knew little of her antecedents. She had suffered severe headaches as a child which were relieved by wearing glasses while in school. Her appendix had been removed when she was 15 years of age, and, when 3 years old she had passed a kidney stone after an attack of hematuria.

In 1935 he had suffered sudden attack of precordial pain radiating to the left arm and, at times, to the left leg. This occurred while she was working as a nurse. She was in bed for 4 months rest thereafter. Electrocardiograms taken at that time were said to have been inconclusive. Many lesser attacks were experienced thereafter at times of increased activity or emotional upset. In March, 1936 he had been referred by her local physician to the clinic laboratory for an electrocardiogram which showed rate 72, P-R interval 6.1 second, tendency toward left axis deviation and moderately low potential it was otherwise normal.

In October 1937 she had suffered an unusually severe attack while preparing breakfast. An oppressive, squeezing precordial pain, which radiated to the left arm and was relieved only by large and frequent hypodermics of opiates, had persisted since that time. A loss of consciousness was said to occur when the pain was most severe, and the husband reported slowing of her pulse to 38 on these occasions. This was never confirmed.

Examination. The patient appeared to be small and prematurely aged but not emaciated. She was 5 feet tall and weighed 9 pounds. Her hair was iron-gray, coarse and dry. Heavy black hair as found on the upper lip and on the chest about the nipples. The pubic hair extended to the umbilicus in masculine configuration and there was a profuse growth of dark hair on the thighs and lower legs. There was a small nodule palpable about the middle of the third rib. Her breasts were small and atrophic appearing. Her lungs were resonant, and breath sounds were normal. Heart border and tones were within normal limits. The pulse rate was 74, the blood pressure 100/60. Neurological examination revealed pathological responses throughout.

Laboratory studies revealed the blood and urine to be normal. The serology was negative. An electrocardiogram then showed rate of 72, P-R interval of 6.6 of second and tendency toward left axis deviation with small Q and isoelectric T.

On November 9, 1937 following the injection of novocaine to verify the position of the needles, 3 to 5

cubic centimeters of about 1 alcohol were injected into the region of the sympathetic trunk between the first, second, third, fourth and fifth ribs on the left side. A mild Horner syndrome and anesthesia of the respective dermatomes were obtained.

The patient remained in the hospital for 48 hours following the alcohol injection, during which time she was free of pain. She was then discharged to the care of her local physician. On December 4, 1937, he was readmitted to the hospital complaining of severe pain in the anesthetic area about the left chest and loss of weight of 15 pounds. His anginal attacks had not appeared. She was given large amounts of vitamin B and high caloric diet and was discharged improved after 10 days.

When next seen on May 1938, the patient stated that after the disappearance of the novocaine in January 1938 she felt better than she had for 30 years until mid-February when mild precordial pain was noticed on few occasions. It coincided with return of sensation in the previous anesthetic zone. These attacks are similar to her previous anginal seizures and increased in severity and frequency until March she had been forced to her bed again when she had remained, getting up only on rare occasions. At first, she had taken codeine, myxal, and nitroglycerine, but none relieved, but more recently these failed and large doses, 5 grains, of morphine were needed to ease the pain during the attacks which were coming three or four times daily and lasting 15 minutes for several hours.

Examination. There were no notable deviations from the previously recorded physical findings at this time. The blood pressure was 115/65, the pulse 72. The lungs were resonant with normal breath sounds, and the heart tones were normal. The laboratory studies of the blood and urine showed them to be normal. The venous pressure was 65 millimeters. A teleroentgenogram of the chest revealed no abnormalities. The electrocardiogram now showed rate 118, P-R interval of 7.4 second, definitely lowered potential, and normal lead II-F.

Operation. As done on May 4, 1938. After pre-anesthetic medication of one-half grain morphine and 1/2 N and local infiltration of per cent novocaine solution as made over the spines of the 7th cervical to the 4th dorsal vertebrae inclusive, and the spaces and laminae of the 1st, 3d, and 5th dorsal vertebrae were removed with the rongeur. A difficulty was encountered over the removal of the laminae on the right side but on the left there was marked ease from removal in the extradural fat. When the laminectomy was completed, plexiform arrangement of veins as noted extradurally on the left side had extended around the left lateral aspect of the dura as far as one could easily follow them. The veins over the left dorsolateral aspect were ligated with silver clips. The dura was opened, but no evidence of intradural extension of the vascular anomaly was found. The 2d, 3d, 4th, and 5th thoracic posterior roots on the left side were secured between clips and



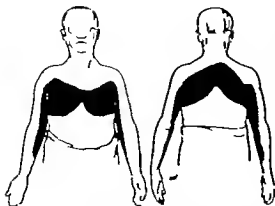


Fig. 6 Case 5, 7 weeks after operation, showing boundaries of area of sensory loss. The dotted area represents the overlap of touch sense as a result of root lesion.

On January 9, 1910, 1 month after leaving the hospital he reported for follow-up studies. He had experienced none of his old anginal attacks but noticed 2 times acute substernal oppression on exertion. He then weighed 77 pounds. His pulse was 76 the blood pressure 100/90. There was no evidence of congestive heart failure. On auscultation the rhythm and quality of the heart sounds were normal. The vital capacity was 2.0 liters. An electrocardiogram showed a rate of 60 regular mechanism, P-R interval of 0.6 of second T was upright, T slightly diphase, and T inverted lead II F was normal. The changes over the previous tracing were not considered significant.

On February 26, 1911 this patient reported that he had extended his activities to supervision of the work about his farm. He could walk the quarter mile to his mill and back to the house without symptoms, but on heavier exertion he noticed feeling of fullness in the neck and chest. His vital capacity was 3 liters.

On March 9, 1911 he came in upon request for follow-up studies. He stated that he had been generally able to do approximately one-third of his former work. In August, 1910, he had made a transcontinental motor trip. He drove the car good part of the distance and had felt no untoward effects from this venture. His activity as limited only by sense of fatigue and substernal constriction. He had no pain at any time. The event that he engaged in too much carpentry, milked more than 8 cows in evening, he would feel rather calm for 3 days.

On examination, then the area of sensory loss conforming to the root lesion of the upper five thoracic roots on both sides as essentially the same as upon his discharge from the hospital. He weighed 73 pounds. The pulse rate was 68 the blood pressure 100/80. The lungs were clear the heart as of normal size and the tones were normal. The lower edge as hard palpable. There was no edema of

the extremities. He had taken no drugs and no medical care since his last visit to the clinic. Blood counts were normal. The cross pressure was 66 millimeters, and the tidal capacity 1.5 liters. Circulation time as arm to tongue, 14 seconds. Arm to lung, 6.5 seconds. An electrocardiogram showed a rate of 7 regular mechanism, P-R interval of 0.5 of second T was upright, T was flattened, and T inverted lead II F was normal. When this was compared to previous tracing, there was no significant difference.

CASE 5. N. 74706. Arteriosclerotic heart disease with somewhat typical anginal syndrome, was controlled by rest or medical management, temporary relief following paravertebral block. His posterior root section with effectively relieved him to useful activity.

Mr. R. L. S. 6 year old son of mill operator in isolated Alaskan community was lost in March, 1910. A brother had died suddenly at the age of 68 of heart attack. Except for an inconsequential head injury in 1906 he had no other illness.

At 5 years, he had been operating a small saw mill which necessitated his doing part of the work himself. In 1906 while doing some heavy lifting his mill, he was suddenly seized with severe pain between the shoulder blades. It radiated toward the chest and around the thoracic wall on both sides. It was of a crushing character. There was no dyspnea, but he was able to walk some for 1/2 mile to his home. The pain lasted 8 hours before physician was called. Then the hypodermic was required for relief. Thereafter he avoided strain.

Soon after, and at several months before the present attack, there was a gradual increase in the frequency and the severity of the anginal attacks. At the onset of the pain followed by nervous excitement. He could not walk more than 75 yards on level ground without experiencing the pain. Rest gave him relief and enabled him to continue on. No narcotics had been necessary after the first attack. The pain at times radiated into the neck and down both arms, more often the right than the left. On number of occasions, he had been awakened at night with the pain and had to move to bed in order to obtain relief. There had been no symptoms suggestive of congestive failure. A clinical diagnosis of probable aortic aneurysm had been made elsewhere.

EXAMINATION. He had an exceptionally well developed muscular build, was 63 inches tall and weighed 90 pounds. His only trace of obesity. The lungs were clear the heart borders within normal percussion limits, and there was no detectable increase in aortic dullness. The heart tones were normal, the rhythm regular. The pulse rate was 84, the blood pressure 110/85. There were no clinical manifestations of organic disease of the nervous system.

Laboratory studies revealed normal blood picture. The serology was negative. The serum was normal. The cross pressure was 8 millimeters. The circulation time as arm to tongue, 6 seconds.

arm to lung, 4 seconds. The vital capacity was 3.5 liters. X-ray examination of chest revealed the heart to be of normal size and contour. The aorta appeared to be normal in both posteroanterior and lateral views. X-ray films of the dorsal spine, the stomach, duodenum, and gallbladder showed no abnormalities.

An electrocardiogram revealed a rate of 72, regular mechanics, a P-R interval of 0.21 of a second, the QRS complex in lead III was of the IV type with a suspiciously deep Q wave. T<sub>3</sub> was isoelectric. The possibility of a previous posterior infarction was considered.

This patient was placed on medical management and carefully followed. It gradually developed that he was having a great deal more pain than he at first intimated. Not only did he have attacks upon walking one to two hundred yards on a level, but he was distressed several times each night. Nitroglycerine afforded some relief but was not at all satisfactory to the patient. A trial with erythroltetranitrate and phenobarbital therapy did not serve to relieve him. A paravertebral block with novocain in the region of the upper four thoracic sympathetic ganglia on both sides was then performed. Following this, he was able for the first time to walk the four blocks from the clinic to his room without pain and without resting. He estimated that he was 90 per cent relieved during the period the novocain was effective. He was well pleased with the result and, after further trial on medical management, requested more permanent relief.

Operation was performed on April 27, 1940. After preoperative medication of hyoscin morphin cactin No. 1, under local anesthesia, a laminectomy was performed in the upper dorsal region, the spines and laminae of the first four thoracic vertebra being removed. The dura was opened and, after a pledget of cotton moistened with novocain was placed upon the roots for a few minutes, the posterior roots of 1st, 2d, 3d, and 4th dorsals on the right and 1st, 2d, 3d, 4th, and 5th dorsals on the left were individually raised on a blunt hook and crushed between the jaws of a hemostat. The dura was closed, because of some little oozing from the heavy muscles in this patient's back, a Penrose drain was left in the wound on closure of the muscles and skin. This was removed 24 hours later.

**Subsequent course.** The second day after operation, this patient developed a cough and a slight elevation in temperature. He was thought for a time to be developing pneumonia. This condition soon cleared, and he made a rather uneventful recovery. He had none of his old pains while in the hospital. There was a loss of sensation over the skin area represented by the sectioned roots. He was discharged from the hospital on May 16, 1940. On May 30, 1940, he reported that he was able to walk ten blocks without any distress. He had noticed an old headache which had bothered him off and on for many years and would become noticeable if he exerted himself too much or became unduly excited. His blood

pressure was 180/70, the pulse 80. An electrocardiogram showed an occasional ventricular extrasystole, a rate of 72, and a P-R interval of 0.22 of a second. There were no significant changes over the previous tracings.

He left for his home in Alaska in June, 1940, and has not been examined since, however, in response to a letter of inquiry in March, 1941, he wrote at length regarding his condition at that time. He noticed at times of undue exertion some mild pains about the shoulders and back and "peculiar feeling bordering on pain seems to radiate to the head. This cannot be described as a pain but starts as a sort of dull, clouded sensation, quickly becoming almost like an ache at the base of the skull and back of the eyes particularly, but enveloping the whole head, giving one the feeling that anything can happen and probably will. I could almost say that there is no symptomatic feeling of constriction or anything of that kind in the chest that amounts to anything. I like to putter around the house and I find that I can perform work such as sawing slabwood in two with an ordinary hand saw and have kept the furnace going all winter with wood cut in this way and all pretty much by my own labor. Shovelling snow and many other chores at which I can take my own sweet time don't bother me at all. A year ago, those things were impossible." His local physician at that time noted as a postscript to the patient's letter "Blood pressure 120/80, heart regular, pulse normal, no pain around chest, some pain in neck and back in case of overexertion."

We are acutely aware of the difficulties encountered in arriving at an accurate diagnosis in some cases of angina pectoris, and we have always adopted a skeptical attitude in interpreting pain of possible cardiac origin. This attitude is proper, especially when the pain has an atypical pattern or whenever the repeated administration of narcotics has been necessary, but in spite of it, this group of patients convinced our numerous associates as well as ourselves that they had true angina pectoris of a completely disabling character. It is noteworthy that in the group selected for operation, objective evidences of heart disease were not extreme. An appreciable amount of congestive failure was lacking in all. Only in Case 1 was there characteristic evidence in the electrocardiogram of a previous cardiac infarction. In the other cases, the electrocardiographic evidence of previous coronary episodes was less conclusive. In only 2 instances were there any significant differences between the tracings made before and after operation. In Case 1, Q<sub>4</sub> was absent before



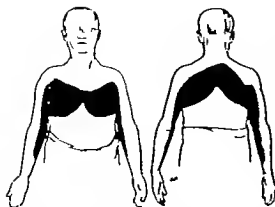


Fig. 6. Case 5. Weeks after operation, showing borders of area of sensory loss. The dotted area represents the overlap of touch sense as is usual in root lesion.

On January 9, 1940, 1 month after leaving the hospital, he reported follow-up studies. He had experienced one of his old anginal attacks but noticed a sense of subternal oppression on exertion. He then weighed 77 pounds. His pulse was 76, the blood pressure 130/90. There was no evidence of congestive heart failure. On auscultation, the rhythm and quality of the heart sounds were normal. The vital capacity was 9 liters. A electrocardiogram showed a rate of 60, regular mechanism, P-R interval of 6.1 second. T was upright, T slightly diphasic, and T inverted. Lead II-P was normal. The changes over the previous tracing were not considered significant.

On February 16, 1940, this patient reported that he had extended his activities to supervision of the work about his farm. He could walk the quarter mile to his mail box and back to the house without symptoms, but on heavier exertion he noticed feeling of fullness in the neck and chest. His vital capacity was 3 liters.

On March 9, 1941, he came in upon request for follow-up studies. He stated that he had been generally well and as able to do approximately one-third of his former work. A guest, 1940, he had made transcontinental motor trip. He drove the car good part of the distance and had felt no toward effects from this adventure. His activity was restricted only by sense of fatigue and subternal constriction. He had no pain any time. The event that he engaged in too soon in carpentry or milked more than 8 cows in an evening, he could feel rather weak for 2 or 3 days.

On examination then the area of sensory loss conforming to the root lesion of the upper five thoracic roots on both sides as essentially the same as upon his discharge from the hospital. He weighed 73 pounds. The pulse rate was 68, the blood pressure 130/80. The lungs were clear, the heart as of normal size and the tones were normal. The liver edge as barely palpable. There was no edema of

the extremities. He had taken no drugs and no medical care since his last visit to the clinic. Blood counts were normal. The cross pressure was 66 millimeters, and the vital capacity 3.5 liters. Circulation time as arm to tongue, 17 seconds; arm to lung, 6.5 seconds. An electrocardiogram showed a rate of 72, regular mechanism, P-R interval of 1.3 of second. T was upright, T was flattened and T inverted. Lead II-P was normal. When this was compared to previous tracing, there was no significant difference.

CASE 5. N 74706. Arteriosclerotic heart disease with somewhat typical anginal syndrome, controlled by rest or medical management. Unrelieved following paravertebral block with an posterior root section with effective relief and return to useful activity.

Mr. R. L. S., 6 year old son of mill operator, an isolated Alaskan community, as first seen March 1940. A brother had died suddenly at age of 68 of a heart attack. Except for a non-sequential head injury in 1916, he had no other illness. For 5 years, he had been operating small mill which necessitated his doing part of the work himself. In 1936, while doing some heavy lifting with mill, he was suddenly seized with severe pain between the shoulder blades. It radiated through the chest and around the thoracic all on both sides. It was not of crushing character. There was no dyspnea, but he was unable to talk some 100 feet to his home. The pain lasted 8 hours before physician was called. Then two hours of morphine required for relief. Thereafter he voided strenuous exertion, and it was several months before the pain recurred. Then there was gradual increase in frequency and the severity of the anginal attacks. At the onset of the pain followed extreme excitement. He could not walk more than 75 yards on level ground without experiencing the pain. Rest gave him relief and enabled him to continue on. No narcotics had been necessary after the first attack. The pain at times radiated into the neck and down both arms, more often the right than the left. On number of occasions, he had been awakened at night with the pain and had to rise up bed in order to obtain relief. There had been no symptoms suggestive of congestive failure. A clinical diagnosis of probable aortic aneurysm had been made elsewhere.

EXAMINATION. He had an exceptionally developed, muscular build, as 68 inches tall and weighed 90 pounds. There was only a trace of obesity. The lungs were clear, the heart borders within normal percussion limits and there was no detectable increase in aortic dullness. The heart tones were normal, the rhythm regular. The pulse rate was 62, the blood pressure 140/85. There were no clinical manifestations of organic disease of the nervous system.

Laboratory studies revealed normal blood picture. The serology was negative. The urine was normal. The venous pressure was 78 millimeters. The circulation time as arm to tongue, 6 seconds.

The remaining cases were followed for periods of from 1 to 4½ years. None have had recurrences of their pain. All have had an increase in tolerance to exercise, and all have adequate "warning signals."

Caution is advised in the selection of cases for this type of procedure.

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operation. Subsequently this component became evident. This might be interpreted as proof of an improved condition of the myocardium. In Case 2 the clinical impression of a painless postoperative coronary thrombosis was substantiated by the electrocardiogram and was verified by autopsy.

Reference to the historical details of the individual cases shows that for the most part the character and radiation of the pain was fairly typical. The fact that in Case 1 the patient in addition to a typical left-sided anginal pain also had pain in a sharply delimited area on the right thigh is interesting as is the fact that novocain administered subcutaneously in this area relieved the pain in the thigh while it continued unabated in the left chest and arm. In the rare intervals that this patient was free of pain before operation there was a cutaneous hyperesthesia of mild degree over this area in the thigh, and for about 1 week following the operation there was a slight hypoaesthesia over the same area. At the time of her last examination this area could not be demarcated. All patients, of course had a permanent sensory loss over the area subserved by the destroyed posterior roots. The area in which there was loss of sensitivity to painful stimuli was greater in each instance than that in which there was loss of the sense of touch. Only 1 patient, Case 5, seemed at all disturbed by subjective paresthesias in the anesthetic areas, and he mentioned them as minor annoyances.

To the best of our knowledge of the 4 patients who have now been followed from 1 to almost 5 years none has had any semblance of painful anginal attacks since the operation. Each has, however, some definite subjective manifestation that warns him when he reaches his tolerance of exertion. This seems in general to be a vague sense of fullness in the neck and chest, with an accompanying feeling of apprehension. In reference to Case 3 we recognize the uncommon occurrence of even extensive cardiac infarction without pain. But, we believe it unlikely for one to live as long after the accident as this patient without more acute subjective distress than she had. It is further emphasized that she too had the afore-mentioned warning signal.

The question of improvement of coronary circulation by such procedure as has been carried out in these cases is, of course interesting involving as it does the question of the vasomotor control of the coronary vessels and the possible vicious circle phenomena sustained by the pain. Concerning this we may call attention to the fact that in all the cases followed there was definite and marked improvement in the tolerance for exertion. Each of them can now do more before reaching the "warning signal" than he could previous to the operation before experiencing pain. We can only suggest that this may be evidence of coronary circulation improvement.

In light of the above observations, it seems to us that the intradural section of the first five thoracic posterior roots effectually severs all cardiac afferent fibers concerned in the production of anginal pain. The operation can be performed largely with local anesthesia and in our hands it does not seem to be a shock-producing as an equivalent paravertebral rami section. The only fatality in the series was a patient with a consistently low blood pressure and a high degree of atherosclerosis. We may consider that such a combination constitutes a contraindication to the use of this procedure. We would also consider any marked degree of congestive heart disease a contraindication. Nor do we believe that patients who can be controlled by medical means with any degree of satisfaction should be subjected to this operation. Alcohol injection is without doubt, a safer procedure and is still to be preferred in most instances, however, for those patients with intractable angina pectoris in whom alcohol injection is unsuccessful and for that small group of exceptionally favorable risks in which one desires to avoid the 25 per cent chance of a poor result following alcohol injection, we believe this procedure to be the method of choice.

#### CONCLUSIONS

The records of 5 patients who were subjected to an intradural section of the upper thoracic posterior roots on both sides for the relief of intractable angina pectoris are presented. One patient died following operative case and operative mortality of 20 per cent

not attributable to the vitamin content. The experiments of McJunkin and Matsui on the epithelial regenerative activity of the fat soluble material of rat tail scrapings seem to be in agreement with this view. Getz appears to have demonstrated that the healing effects of cod liver oil in experimental tuberculous lesions reside neither in the fatty acids nor in the vitamin A and D contents, but in an unknown factor in the unsaponifiable residue.

Nearly all of the workers with natural cellular products have regarded the materials responsible for the increase in cellular proliferation to be products of tissue destruction. In our laboratories techniques have been developed for the controlled injury of cells under reproducible and more or less quantitative conditions, and we believe that our experiments indicate that cells subjected to injuring agents secrete or release proliferation promoting (and respiration stimulating) substances as a direct response to the injury. These factors are not solely cellular destruction products, nor do they consist wholly of nutrient materials, but rather they may be hormone-like substances, in the original sense of Brown-Séquard and d'Arsonval, secreted by injured living cells into the intercellular fluid. For this reason they have been spoken of as "intercellular hormones." In our investigations (Sperti, Loofbourow, Fardon, Cook and collaborators), yeast, bacteria, algae, and animal tissues injured by controlled dosages of lethal ultraviolet radiation and x-rays as well as by chemical injury, mechanical injury or trauma, and by oxygen-want have been shown to produce factors which stimulate the proliferation of cells *in vitro* and, at least in one instance, *in vivo*. The fact that many of our studies have used yeast as a test organism does not deprive them of clinical interest, since it has been shown that, in many cases, the tissue active factors also stimulate yeast proliferation, and the latter is experimentally much better suited for quantitative assay purposes.

The evidence seems to show that injured living cells form hormone-like proliferation promoting factors as a specific response to injury although the release of dead cell disintegration products and increased permeability of the cell membrane may account for some of the activity in crude preparations.

Specific experimental results with cell suspensions which support these contentions include the following:

1. A given dosage of injuring agent, such as ultraviolet irradiation, applied at low intensities to a suspension of cells over a long period of time

so that the rate of killing is low as compared with the application of the same dosage at high intensity for a shorter and more rapidly lethal period results in the formation of greater quantities of proliferation promoting substances, the yield, within limits, being closely proportional to the time required to kill the cells.

2. A comparison of the curves for the rate of killing by lethal ultraviolet with the curves representing rate of production of growth factors shows that the maximum production of proliferation factors takes place before appreciable killing occurs.

3. Application of a given dosage of injuring agent, such as ultraviolet, followed by the killing of the surviving cells by other means, as by heat or grinding, produces more potent growth promoting extracts than by reversing the process, i.e., first killing (by heat or grinding) and then applying the injuring agent.

4. Experiments on the use of various media for suspending cells during the application of injurious radiation show that nutrient or nontoxic isotonic media allow the greatest yield of the growth factors for the same dosage of injuring agent.

5. Carbon dioxide increases the yield of active factors in the intercellular fluids without killing the cells.

6. Carcinogenic hydrocarbons, such as 1,2,5,6-dibenzanthracene, increase the yield of active factors by cell suspensions without appreciable killing of the cells.

These findings receive further, although less quantitative, support from experiments on the effects of trauma on tissues in culture. Certain of these experiments are considered in the following section.

#### THE BEHAVIOR OF GROWTH PROMOTING FACTORS IN TISSUE CULTURE

It has been shown directly and indirectly by several investigators that growth promoting substances are released by excised fragments of embryonic and adult tissue *in vitro*. Explanted pieces of embryonic tissue in simple saline solution show migration and cell division. Fischer (1917) holds that such cultures grow at the expense of nourishing and growth promoting substances liberated by the cells of the explant. Carrel (1913), working with cultures of connective tissue, demonstrated the remarkable power of embryonic tissue extract upon the multiplication of such cells. It was also shown by Carrel (1912) that extracts of adult spleen, leucocytes, and Rous chicken sarcoma considerably accelerated the growth of such cul-

# THE WOUND HORMONE CONCEPT IN WOUND HEALING

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IN this paper we wish to indicate briefly the position of chemical substances, produced by injured living cells, as the possible natural stimulus, or so called formative stimulus, to wound repair and, in particular, to relate certain studies carried on in our laboratories of this problem. We wish also to broaden the wound hormone concept to include not only materials which stimulate cellular proliferation but also materials which may accelerate cellular metabolism during the healing process.

It is not our purpose to provide an exhaustive review of "wound hormones." Nor is it the intention of the authors to review the manifold aspects of wound healing. This has been done in the excellent paper of Arey.

## WOUND HORMONES

Many years ago in 1858, Virchow suggested that healing was the result of a direct stimulation of the cells by the traumatism. Wiesner appears to have been the first, in 1891 to suggest that the traumatic effect is an indirect one the injured cells releasing substances (wound hormones) which stimulate the normal cells to proliferation. These suggestions were made with regard to plant tissues. Not until 1913 and later did the botanists Haberlandt and Reiche produce further evidence to substantiate this hypothesis. Recently a series of researches by Bonner and English has resulted in the isolation from plant tissues and subsequent synthesis of a substance which they believe to be a plant wound hormone and have accordingly named traumatin, although no evidence has been adduced for its increased formation as a result of injury.

The application of the wound hormone hypothesis to animal tissues likewise suffered a severe time lag. In 1891 Welch presented the hypothesis that the formative stimulus of Virchow consists of substances acting from without which directly stimulate cells to growth and proliferation the stimulating principle would be, therefore, chemical in nature. (Arey) Not until 1922 and 1924 did Nawitsch present preliminary information concerning the existence of wound hormones. Necrohormones derived from injured tissues were studied by Lorin Epstein and

Fraenkel. Carrel, as a result of his long series of studies extending back to 1912, observed that definite growth promoting substances are secreted by leucocytes and are present in embryonic juices. He suggested (1924) that "lymphocytes," elaborated by the leucocytes, were the polar stimulus to repair in animal wounds. Later (25) he stated that, in superficial epithelial wounds, reparative stimulus must consist of materials in the injured cells themselves. It was believed that Carrel and Baker that the growth activity could be attributed to split products of proteins (peptides) and to glutathione and benzoyl. Many researches conducted by Hammett in both plant and animal tissues led him to the conclusion that the sulphydryl radical is the essential factor for cellular proliferation and applications of this conclusion have been made to wound healing by Hammett and Reimann.

Based upon these observations, many tests of embryonic extracts, leucocytes, protein decomposition products, and tissue destruction products have been made on experimental and clinical wounds, usually with a reported lessening of healing time. References to this work are given by Arey.

It is not within the province of this paper to discuss in detail the use of many other substances which have been employed to promote wound healing such as urea and allantoin. Although these substances occur naturally, as, for example, in the excreta of maggots, there is no evidence in which the authors are aware to link them with the primary stimulus to wound repair as the result of the wounding itself. Similarly fish liver oil, although natural products, do not appear to be associated with wound repair in the manner of which we are speaking. The considerable literature on this subject is briefly reviewed by Hixon who points out the lack of unanimity of opinion as to the nature of the active factor in the oil, although this has been variously identified as vitamins A and D and with fatty acids. The present case for vitamins is outlined by Hixon. Unpublished experiments on animals in our laboratories, in which were used not only fish liver oil but also fat soluble preparations from beef liver, rat liver and spleen, have led us to believe that the proliferation promoting activity of the oil is accumulating in the vitamin containing fractions.

From the Research Laboratories of the Institutum Delfi Thomae

issue metabolism. Since energy for proliferation must be supplied by metabolism, the well known fact of high metabolism of rapidly growing normal tissue, such as embryo tissue, would be expected. A similar relation holds in aseptic wounds. Gaze and Gissel, by means of the Warburg technique, measured the respiration and anaerobic glycolysis in aseptic wounds of the human skin. It was found that shortly after infliction of the wound, a rapid fall in metabolism occurs, corresponding to the destruction of tissue. When repair begins, a rise in metabolism occurs above normal, and the metabolism finally declines to the normal level. Similar findings were obtained from study of the metabolism of the Achilles tendon of the dog. It has been pointed out that respiration may be lowered in a number of pathological conditions or by toxic agents and that its measurement may serve as a criterion of the vitality of the skin and, for that reason, may be a useful adjunct in dermatology (Adams, Amersbach and associates, Cook).

In our laboratories the effects of injuring agents such as ultraviolet and  $\gamma$ -radiations, on the respiration of cell suspensions have been studied, conditions similar to those employed in the proliferation investigations being used. It was found that mild irradiation caused an increase in respiration while intensive irradiation, with resulting destruction of most of the cells, caused a decrease or cessation of respiration (Fardon and associates, 1937). It was shown that such irradiation caused the release by the injured cells of a factor (or factors) which could be separated from the cells and which was active in increasing the respiration of fresh cell suspensions. Thus, it appears that cells, under the influence of injuring agents, release into the intercellular fluids substances which stimulate the proliferation and respiration (and also, less extensively investigated, the glycolysis) of cells. Effort is being expended on the preparation, fractionation, and characterization of these substances and their relation to other recognized materials (Cook, Norris, and collaborators). As a result of these studies we believe that the injury of cells causes them to release (and probably to synthesize in increased quantities) not only chemicals which induce more rapid proliferation but also chemicals which tend to restore the metabolism which has been lowered as a direct result of tissue destruction. Present indications are that the growth and respiratory stimulating factors are distinct, and, at least under our experimental conditions, relatively greater proportions of the growth factors are produced by injury.

## NATURE OF RESPIRATORY PROMOTING AND PROLIFERATION PROMOTING FACTORS

1 *Respiration promoting factors* Little is known as yet of the chemical nature of the respiratory factors with which we have been dealing and consequently we are unable to state how these factors may fit in with the recognized respiratory systems and to just what extent they may be identical with known respiratory intermediaries. Our efforts in connection with both the respiratory and proliferation factors have, until recently, been directed primarily toward the physiological aspects of the problem, i.e., the effect of injury on the production of these materials, and less toward their nature and mode of action. Certain indications are available, however (Cook and associates) in crude extracts undoubtedly mixtures containing both coenzyme-like substances and oxidative substrates are present. There is evidence that a variety of materials, more or less specific as to tissue, are involved. It has been possible to eliminate a variety of amino acids, members of the vitamin B complex (thiamin, riboflavin, nicotinic acid, pyridoxin, pantothenic acid) and other substances as major sources of activity on yeast respiration (Cook, Walter and Eilert, 1940) as well as on skin respiration (unpublished) under our experimental conditions. The active materials appear to be free of protein and sulfur, and all the active water-soluble preparations thus far obtained contain nitrogen. A material active in increasing liver respiration has been concentrated by fractional electrical transport and is definitely acidic in nature. Certain of the common participants in cellular oxidation systems, such as the thiamin containing and alloxazine containing coenzymes and coenzymes I and II, appear to be eliminated by the lack of correlation between ultraviolet absorption and respiratory activity. Certain fatty substances which, in nontoxic concentrations, increase the respiration of yeast have been shown to be fatty acids acting as substrates.

2 *Proliferation promoting substances* It was early established that there was a correlation between the proliferation promoting capacity and the amount of ultraviolet absorption at approximately 2600 Angstroms in the crude concentrates of proliferation promoting factors from both yeast and animal tissues (Loofbourow, Cook). This was taken as evidence of a nucleic acid-like nature of the proliferants. Recently, however, experiments have shown that, while an increase in nucleic acid (or similar substances) can be demonstrated in the ultraviolet injured cells either directly (by the quartz microscopic technique) or by isolation, and

tures. Working with cultures of adult tissue, Drew found that products of autolysis from disintegrating adult cells initiated the multiplication of such tissue and produced growth of explosive character. However making subcultures of these in fresh media and again adding the autolyzed tissue extract, he found rapid degeneration to set in while the cultures which did not receive a second dose of the extract continued to grow vigorously. Walton noted that if a piece of rapidly growing tissue was cut in two growth was delayed on the cut edge (he was of the opinion that this was apparently due to trauma), so that when the cells from the uncut edges had formed a halo of branching cells spreading out into the plasma, only a few cells were projecting from the cut portion. These cells grew rapidly however and after the second or third day nearly equalled in width the outgrowth from the uncut edges. Walton apparently made no special issue of increased growth after injury but was mainly interested in the lag period.

Fischer in studying the physicochemical nature of growth promoting substances, employed various methods of obtaining embryo tissue extracts. He found (917) that extracts obtained by simply cutting embryos in pulp with a pair of scissors gave greater activating power than when this pulp was subjected to grinding in a mortar with Kieselguhr. These results suggest to us that injury rather than complete destruction of the cells produces the highest concentration of growth promoting substances. These experiments were repeated in our laboratories with the same results obtained by Fischer. Further work by Fischer (930) on the healing of wounds *in vitro* has shown that after successive traumatization the cultures grew definitely faster than the undamaged controls. He observed also that the speed with which wound healing takes place in such cultures could be measured and was found to be inversely proportional to the age of the culture.

To demonstrate the liberation of growth promoting substances from injured tissue, a series of *in vitro* experiments was initiated in these laboratories. Embryonic chick heart was chosen for explantation, and plasma Drew's solution for the medium. The tissue fragments for the control cultures were immediately transferred to hanging-drop slides. The pieces of tissue used in the experimental group were placed in a serological tube and washed thoroughly with Drew's solution by shaking gently for 30 seconds. This procedure was repeated six times with every piece of tissue, the old fluid each time being pipetted off and replaced with fresh Drew's solution. Thereafter

each fragment of tissue was transferred to a culture and incubated with the control group which was not washed. Growth measurements were taken after an incubation period of 48 hours. The results may be summarized as follows: Twenty four per cent of the unwashed tissue showed growth ranging from *no growth* to *fair* while in the washed tissues 53 per cent showed either *poor* or *no growth*. Conversely, only 5 per cent of the washed tissues showed growth ranging from *fair* to *very good* while 70 per cent of the unwashed tissues exhibited growth ranging from *fair* to *very good*. These results clearly indicate that washing the tissue before explantation removes much of the growth stimulating substances produced through injury by cutting and is reflected in subsequent reduced growth.

Another series of *in vitro* experiments was performed in these laboratories to demonstrate not directly the stimulation of growth as a result of injury. To illustrate with any degree of directness that injured tissues liberate growth promoting substances entails several technical difficulties. After a fragment of tissue in a plasma clot is cut and oriented it is often difficult later to recognize the cut portion. It frequently happens—although the cut portion be recognizable—that the resultant ubiquitous migration of cells produces a pattern which gives the false impression of uniform growth from all portions of the tissue. To circumvent these difficulties a tissue, as chosen in which the cut portions were easily distinguishable and relatively remote from the most portions. For this experiment intestine removed from 4 to 18 day old chick embryos was carefully cut into transverse sections not exceeding 2 millimeters in length. In transferring the sections to the cover slips, special precautions are taken not to injure any portion of the muscular coat of the intestinal wall. Each fragment of intestine was so oriented as to make clearly visible the two cut ends. Active growth in every instance proceeded from the cut or injured portion of the intestine sections.

In summarizing the experimental results of *in vitro* investigations, it appears evident that growth promoting factors are liberated from tissues in culture as a consequence of injury.

#### METABOLISM

While considerable effort has been devoted to the stimulation of proliferation in wounds—including use not only of products of cellular injury but also of allantoin, urea, fish liver oils, methylglucosides, etc.—much less attention has been devoted to the problem of the effect of injury on

# A SIMPLIFIED TECHNIQUE FOR THIGH AMPUTATION

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ONE hesitates to write an article on a so called "new technique" for thigh amputation. So many operations have been devised that it is difficult to imagine another new procedure. The procedure herein described, however, is the result of operations previously described and so modified that a simple effective technique has resulted.

This series comprises 40 low thigh amputations performed by the method to be presented. Our results have been good and the mortality respectably low. In the 40 cases there were 3 deaths, none of which occurred immediately following operation. Twenty of these amputations were done by the author, and the remaining 20 by two surgical residents at Cook County Hospital (Drs J W Howser and W N Knudsen). By paying strict attention to a few details and by carrying out the procedure in a step by step manner, the routine developed has resulted in a rather simplified amputation.

Linson and Wright, McKittick and Root, Callender, and Samuels have contributed much to this subject, especially in the diabetic patient. Their experiences tend to show that a supracondylar type of amputation, even in the presence of infection, should be a relatively simple operation and should not result in a high mortality. All of these authors emphasize the importance of good preoperative and postoperative care.

While generally accepted that spinal anesthesia is the anesthetic of choice in the aged and in the diabetic, Samuels has reported excellent results with cyclopropane or nitrous oxide. He states that since spinal anesthesia has a tendency to diminish the blood flow in the extremities, this may be looked upon as a contraindication for its use in amputations. He has suggested that this may play a role in thrombosis in the arteries of the opposite extremity. In our series of 40 cases, 20 patients were anesthetized by cyclopropane and 20 with nitrous oxide. Ether has been abandoned. We believe that cyclopropane is the anesthetic of first choice. In the absence of cyclopropane our second choice is ethylene. The immediate postoperative course in these patients has been most gratifying.

The draping of the patient, which at first thought appears to be an indifferent step, should

be done by the surgeon himself. The draping should be done in such a way that the second assistant may execute internal rotation, external rotation, or elevation of the leg at any time without hindrance to motion and without danger of contamination.

The technique about to be described is different in that flap formation is considered unnecessary, no tourniquet is used, drains have been abandoned, and cotton is used for suture material instead of catgut.

The position of the surgeon at the operating table is important. He should occupy a position opposite the leg which is to be amputated. The reason for this is that since no tourniquet is applied he should have ready access to the popliteal vessels. These vessels may be approached easily through the medial aspect of the popliteal space. To attempt a lateral approach to the popliteal vessels is both cumbersome and difficult. The first assistant stands directly opposite the surgeon. The second assistant is at the foot end of the table, manipulating the leg into any position which the surgeon might desire. After a surgical team has gone over the procedure a few times, these manipulations become automatic.

The skin incision is so placed as to permit amputation at the lower third of the thigh. This is the generally accepted site of choice. The incision is made with a new, sharp scalpel blade. Since tissues, especially tissues of lower resistance are readily traumatized by dull blades, we prefer to use a medium sized detachable blade. With the leg fully extended, the surgeon feels the upper border of the patella, and at this point makes a simple circular incision (Fig 1, a). It has been a great source of relief to us to find that this simple circular incision allows the flaps to fall together and heal better than do other incisions previously used by us. This incision includes skin and superficial fascia. Over the medial side of the incision, the internal saphenous vein is identified, ligated, and severed. It is recalled that this vein runs in the superficial fascia and on the fascia lata. We utilize this vein as a guide to the sartorius muscle. There is no undermining or undercutting of any tissues.

The incision having been completed a fresh scalpel blade is taken and a similar incision is made in the deep fascia. Our attention is now directed to the four muscles which lie medial to

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while a parallel increase in growth potency also takes place (Loofbourow et al., 1941) yet it is possible by the technique of chromatographic adsorption to obtain potent extracts which do not show selective ultraviolet absorption. No correlation was observed between ultraviolet absorption at 2600 Angstroms and growth potency of fractions from uninjured cells (Cook Hart, and Stimson, 1940). Davidson confirmed the growth promoting properties and the increased content of purine, nucleotide and nucleoside nitrogen in the cell free fluids from ultraviolet injured yeast cells and also found a large increase in amino nitrogen. It may be recalled that Caspersen has demonstrated an increase in nucleic acid during cellular division and Fischer (1939, 1940) believes that a nucleoprotein is responsible for the proliferation effects observed by him and previously referred to in this paper. A preparation from beef embryos based on Fischer's work and known as epicutan is being investigated in the healing of war wounds in England.

A series of unpublished experiments comparing cell free extracts from ultraviolet irradiated yeast with the known growth factors for yeast (Inositol, thiamin, biotin, vitamin B<sub>6</sub>, pantothenic acid and amino acids) has shown that, while part of the activity of crude extracts is accounted for by certain of these substances, there is yet a residual effect due to substances not yet recognized. This is confirmed by work of Williams and associates.

Injury therefore, would appear to result in the release of proliferation promoting substances some of which represent an increased product of known materials, but some of which are unknown. It may be mentioned that no evidence has been found to relate these materials to the sulfhydryl compounds of Hammett since none of them contain sulfur.

#### SUMMARY

Evidence is presented that living cells, upon injury produce or release substances which promote the proliferation and metabolism of surviving cells. While crude preparations from injured cells contain cellular disintegration products which can serve as nutrients, it is believed that injured cells secrete into the intercellular fluid additional materials which may be hormone-like in their action, in the original sense of Bant, Séguard and d'Arsonval, and which, therefore, may be termed intercellular hormones. It is believed that these substances are of importance in wound healing and may constitute the local stimulus of Virchow. The efficacy of such contemporary modes of therapy as the Oort treatment may be due in part to the retention of such substances at the wound site. The work reported herein is being extended to *in vivo* studies of animal and human wounds and will be reported hereafter.

(A full bibliography will be included in the reprint.)

are placed proximally around the artery and vein, tied and cut short. A double ligature is placed around the distal aspect of the vessels. This distal ligature is placed only to prevent regurgitant venous bleeding. A hemostat may be used in its place. We have found, however, that such a hemostat dangling in the wound obscures the field. The vessels are now severed between the distal two ligatures. The atheromatous condition of the vessels are usually seen at this stage of the operation.

The sciatic nerve should now be carefully dissected out and brought up with a wet tape. Some authors prefer to refer to the nerve as the popliteal in this locality. Since the operation is performed above the popliteal space, the term sciatic is more appropriate. The nerve is delivered to the medial surface of the thigh, caught with a toothless, non-traumatizing forceps, severed, injected with 1 cubic centimeter of absolute alcohol and ligated with a single cotton suture. In some of these cases we have intentionally omitted the injection of alcohol into the nerve. These patients complained of a greater amount of postoperative pain. Such pain lasted about a week. Based upon this experience, we consider the injection of the nerve essential. This also for the purpose of preventing the development of amputation neuroma (Fig 2, a and c).

The second assistant is instructed to rotate the leg and thigh medially. This brings the two lateral structures which are to be divided, into view. These are the tendon of the biceps femoris and the iliotibial band (Fig 2, d). The biceps tendon is the most dorsal structure in this region. It can easily be followed to the head of the fibula if one is not sure of its identity. This tendon is divided. The iliotibial band runs a full finger's breadth in front of the now divided biceps tendon. It too is severed.

Having detached the medial, lateral, and posterior structures, this leaves only the anterior muscle mass, the quadriceps femoris muscle, to be divided. Immediately posterior to its medial border the adductor magnus tendon is found. This entire mass is cut through at that level to which the skin has retracted. The incision through the muscle mass is carried down to the bone. No retraction of the muscle is necessary since it retracts by itself. The periosteum is incised with a circular sweep around the femur. The periosteum is then elevated proximally and distally with a periosteal elevator (Fig 3, a).

It is now noticed that the soft tissues fall away from the femur, but remain attached at only one point. This point is posterior where the muscles

The periosteum is elevated above and below, and the bone is sectioned 2 inches proximal to the skin incision.

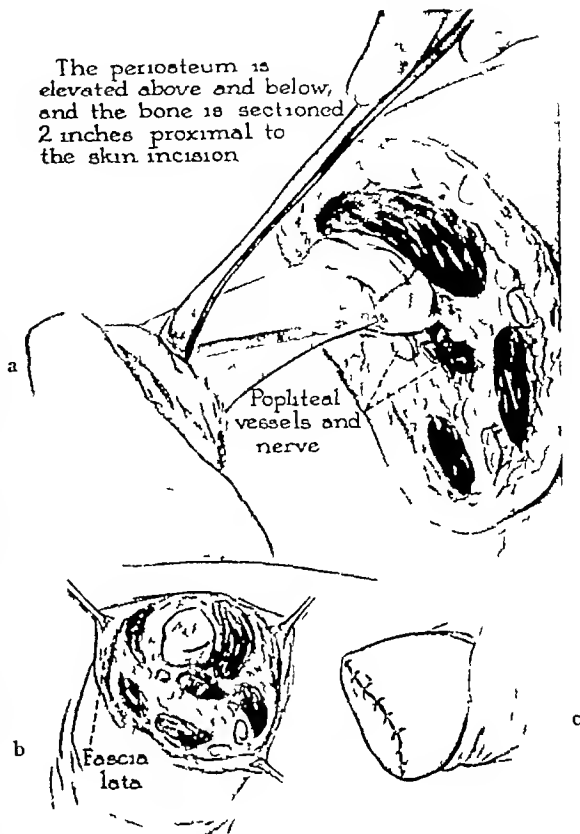


Fig 3 a, Elevation of periosteum following division of sciatic nerve. The nerve retracts. The edge of the nerve is depicted in the figure for anatomical orientation. b, The fascia lata is identified and grasped with Allis forceps. c, Closure with interrupted sutures.

are attached to the linea aspera. If a few light strokes are made with the scalpel along this posterior attachment to the linea aspera, the entire soft tissue mass falls away from the femur and can now easily be retracted upward (proximally).

If the bone is sawed through, 2 or 3 inches above the level of the skin incision, an excellent stump results. We have no difficulty with protruding bone or pressure necrosis from the underlying bone. The bone can be removed high enough, only if the attachments to the linea aspera are detached posteriorly. This point cannot be overemphasized. Some surgeons insist that curetting of the bone is essential. We have avoided it.

The leg being amputated, the second assistant is now free to hold the stump. He holds the stump in such a way as to permit its cut surface

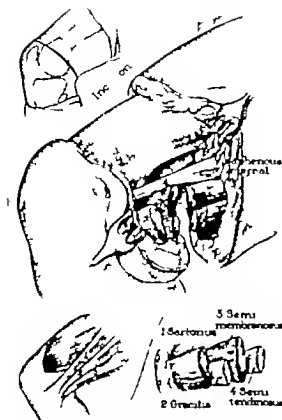


Fig. 1. a, Superpatellar circular incision. b, Simplified division of medial musculature semitendinosus intact. c, Anatomy of medial neurovascular.

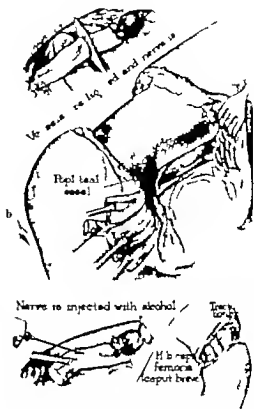


Fig. 2. a, Isolation of popliteal vessels. b, Division of sciatic nerve. c, Traction on nerve and injection of alcohol. d, Anatomy of lateral musculature.

the popliteal spaces. These are the sartorius, gracilis semimembranosus, and semitendinosus (named from superficial to deep) (Fig. 1 b and c). They are easily identified and separated from each other. They do not require ligation since no large vessels run through them. Two of these four muscles, the sartorius and the semimembranosus, are muscular in this region; the remaining two, the gracilis and semitendinosus, are tendinous. We have noticed no ill effects as a result of cutting through the muscle. From the standpoint of infection, particularly the gas bacillus type, the importance of a sharp scalpel and the avoidance of crushing these structures with ligatures or hemostats cannot be overemphasized. In our series we have not seen a single case of gas gangrene.

Following the division of the four medial muscles, the next step is the isolation, ligation, and division of the popliteal vessels. This step

becomes simple if the following maneuver is executed. The index finger of the right hand is placed against the posterior aspect of the femur. The bone should actually be felt. This finger is then thrust laterally, hugging the posterior surface of the femur all the way. Having done this, the popliteal artery and vein may now be hooked by the index finger and delivered medially. The popliteal space is filled with the peculiar watery type of fat. Some of this fat clings to the vascular bundle. There is no difficulty, however, in feeling the pulsations of the popliteal artery through the fat. This liquid fat is easily spread off of the vessels by means of a moist gauze sponge. The vessels now stand out in bold relief, especially the artery, the pulsations of which are distinctly audible. An attempt is made to separate the artery from the vein (Fig. 2 b).

The vessels are ligated with No. 4 cotton ligatures which have been doubled. Two ligatures

are placed proximally around the artery and vein, tied and cut short. A double ligature is placed around the distal aspect of the vessels. This distal ligature is placed only to prevent regurgitant venous bleeding. A hemostat may be used in its place. We have found, however, that such a hemostat dangling in the wound obscures the field. The vessels are now severed between the distal two ligatures. The atheromatous condition of the vessels are usually seen at this stage of the operation.

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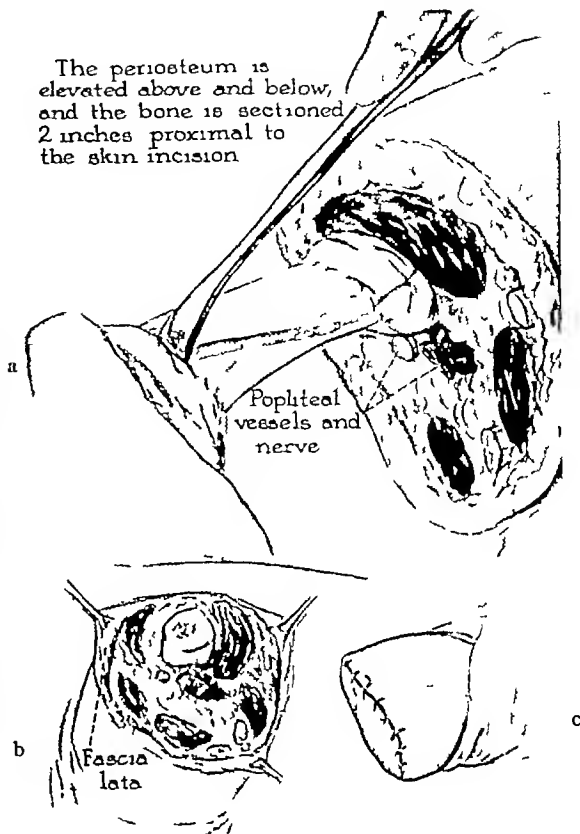


Fig 3 a, Elevation of periosteum following division of sciatic nerve. The nerve retracts. The edge of the nerve is depicted in the figure for anatomical orientation. b, The fascia lata is identified and grasped with Allis forceps. c, Closure with interrupted sutures.

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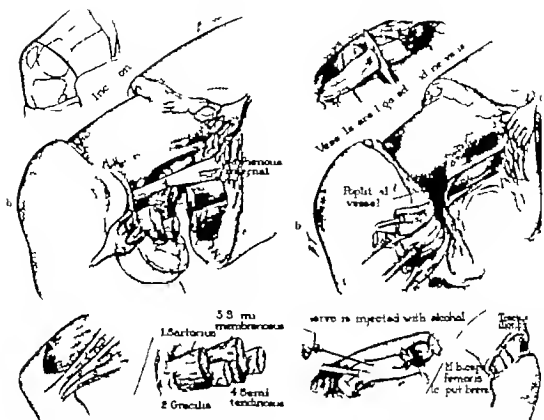


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The vessels are ligated with No. 24 cotton ligatures which have been doubled. The ligatures

# HABITUAL DISLOCATION OF THE SHOULDER JOINT

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RECURRENT dislocations of the shoulder joint have been recognized for centuries, Hippocrates being credited with the first description. However, as in many other lesions, treatment has not kept pace with clinical recognition. This, of course, is due either to (1) lack of full understanding of the lesion, (2) paucity of therapeutic measures, or (3) inability of the body to repair itself.

Centuries ago the ailment was treated by plunging a hot iron into the axilla. It is hard to say how many cures were derived from this very radical procedure. No real rationale can be attached to the method as far as the operators were concerned, since microscopic anatomy of repair as well as of gross lesions were poorly understood.

In 1870 Theodore Kocher, of Berne, described his manipulative principles of reducing anterior dislocation of the shoulder. These principles, although condemned by some, are still in modern textbooks. In 1882, Cramer and others practiced resection of the humeral head for this condition. By 1888 Albert was advocating arthrodesis of the shoulder joint. Ricord, in 1894, was one of the first to do a capsulorrhaphy. Hildebrand attempted to deepen the glenoid fossa in 1902. In 1903 C Beck plicated the capsule and threaded silver wires through the acromion process and head of the humerus. Five weeks later the wires were removed. Six months later the result was still good.

By 1909 Clairmont and Ehrlich detached a part of the posterior deltoid, passed it beneath the subcapital portion of the humerus and reattached the muscle flap to the muscle body anteriorly. In 1917 Clairmont strengthened the coracoclavicular ligament. This same year, Joseph gave the technique of tenosuspension by placing drill holes through the acromion and tuberosity of the humerus. In his method, fascia lata was used as the suspending material.

M Henderson devised a similar operation in 1921 but used the peroneus longus tendon instead. His article of that time states that dislocation of the shoulder is not more common than demonstrates how wonderful are the mechanism and muscle balance that prevent such an occurrence. In further support he says, 'I am con-

vinced that some altered muscle tension has to do with the production of the dislocation. This muscle tone may be caused by an alteration in the relationship of muscle to its original insertion, for example, it has been claimed by many that the relationship of the supraspinatus and infraspinatus to their insertion is altered by their being partially torn off at the time of the original injury.'

In an article written in 1926 Henderson states that, in recurring dislocation of the shoulder, the head of the humerus is practically always downward and forward. There is no mention of disturbed muscle relationship. In his series capsulorrhaphy gave 42 per cent cures after 5 years. However, Henderson believed that tenosuspension was better.

Carrell, in 1927, was using the long head of the biceps brachii for the repair of recurrent dislocations. In Carrell's own words, "The biceps tendon was sectioned at the lowest level and reflected from its sheath up to the point where it emerges from the capsule. The distal end was fashioned into the coracoid head of the biceps. A strip of fascia 6 or 7 inches long and 1.5 inches wide was securely fastened to the free end of the biceps tendon. A posterior incision was then made, extending from the acromion downward on the posterior surface of the arm 4 inches. The deltoid was separated and the teres minor exposed. The biceps and fascial strip was now passed under the neck penetrating the capsule, in and out at two points, it was then threaded on a special instrument fashioned like an aneurysm needle. The instrument hugs the capsule and emerges just above the teres minor, where it is secured through a drill hole in the acromion. Carrell states that this method is good for any type of dislocation.

Nicola in 1929 presented, 'A new operation,' for the repair of recurrent anterior dislocation of the shoulder. He uses the long head of the biceps brachii and threads it through the head of the humerus. Nicola argues that this operation can be used when the pathological condition is due to bony, muscular, or capsular defects or to any combination of these defects.

In 1938 Bankart published an article entitled 'The Pathology and Treatment of Recurrent Dislocation of the Shoulder Joint,' in which he stresses that recurrent dislocation is not the ordi-

From the University of Illinois College of Medicine

to face directly upward (Fig. 3 b). The fascia lata is easily identified as a strong layer completely encircling the thigh and surrounding the muscles, vessels, and nerves. This layer is picked up with Allis forceps and sutured, transversely, with a few interrupted cotton sutures. The muscles are not sutured together. The approximation of the fascia lata guides the muscles over the end of the bone so that the cut muscle surfaces touch each other. In this way no dead spaces result, and no sutures are placed in the muscles.

All that remains now is to approximate the skin edges. The ease with which this is accomplished is gratifying. It is surprising to find that although no flaps have been fashioned, two well approximated flaps result. At each corner two small skin tabs, dog ears, result. These may either be trimmed off or left alone. We prefer the latter since we have found that the skin at the edges of the wound shrinks and retracts by itself.

The resulting scar is at the end of the stump. This may be criticized by some as producing a painful weight-bearing stump. This may not be a valid criticism since the artificial limb of today does not apply pressure to the end of the stump alone. Instead, the pressure is applied in "bucket fashion" to the sides of the extremity and to bony prominences, as the ischial tuberosities as well as the end of the bone. This, however, is still a moot question.

A light dressing is applied and is held in place by adhesive tape which is not applied too tightly. Circular bandages have been abandoned because they have a tendency to constrict and interfere with an already impaired circulation. No splint traction apparatus is applied.

These patients are told to move their stumps as early as possible. An attempt is made to have

them out of bed on the second or third postoperative day. This is not always possible but the rule in the majority of cases. Diabetic patients immediately returned to their diet because of rigidity. Every other suture is removed on the fifth or sixth postoperative day and, if there is no gaping, the remaining sutures are removed on the following day.

In none of these 40 cases were drains used. To drain or not to drain these stumps is still a moot question. We have adhered to the teaching that a drain acts as a foreign body thereby causing drainage, delays healing, and encourages infection.

Cotton sutures (4) have been used throughout the entire procedure because it does not produce draining sinuses and because it results in a smoother and simpler operating technique.

#### CONCLUSIONS

1. A technique for thigh amputation has been described.

The importance of no flap formation and the omission of the use of the tourniquet has been stressed.

3. Drains in these postoperative wounds have been discontinued.

4. The possible disadvantages of spinal anesthesia in these cases have been pointed out.

5. Cotton was used as the suture material.

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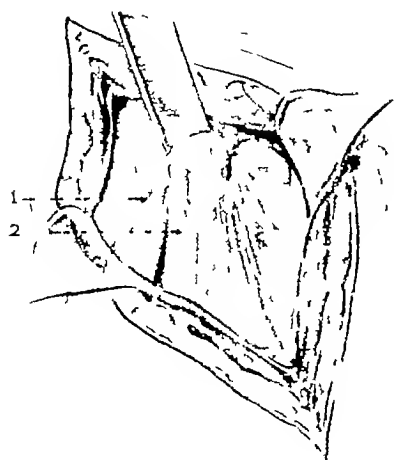


Fig 3 Chiseling free the tip of the coracoid containing the pectoralis minor, 1, and biceps and coracobrachialis

concerned Our present interest centers in that part of the capsule anterior to the shoulder joint. Slightly below the coracoid process is an opening which is the foramen allowing communication between the shoulder joint and subcoracoid bursa. Occasionally this foramen is beneath the uppermost fibers of the subscapularis. In order more thoroughly to examine the capsule let us enucleate the humerus from its end of the capsular tube (Fig 1a).

On inspection one does not notice anything unusual about the capsule but upon taking it between the thumb and index finger two areas of thickening can be felt. These bands begin near the upper border of the glenoid and run forward and downward toward the humerus. The upper is known as the middle glenohumeral ligament (Fig 1a, 2), and the lower as the inferior glenohumeral ligament. There is yet a third which, because of its location, cannot be so readily palpated. It is the superior glenohumeral ligament. It begins at the upper margin of the glenoid, bifurcates to pass around the origin of the long head of the biceps tendon, and continues to the neck of the humerus superiorly (Fig 1a, 1). It lies directly under the coracohumeral ligament and should not be confused with it.

On inspecting the inside of this capsular tube, one notices at its base the glenoid fossa and about its periphery where it joins the capsule, there is a raised fibrocartilaginous band known as the labrum glenoidale or glenoid ligament (Fig 1a, 4). Cunningham states that it is within the fibrous

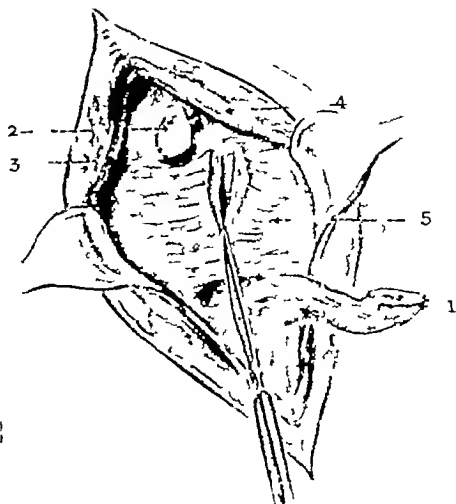


Fig 4 Cutting the subscapularis, 5, not too close to its insertion into the capsule and humerus. 1, Reflected tip of coracoid with biceps and coracobrachialis; 2, stump of coracoid process; 3, pectoralis muscle; 4, deltoid muscle

capsule and attaches to the margin of the glenoid cavity, and that to some slight extent it increases the security of the articulation.

In the dissecting room we examined about 40 shoulders and found 6 instances of tears in the anterior capsule of the shoulder joint. Three tears were between the bony glenoid margin and the glenoid ligament (Fig 1b, c). Two presented a rent between the glenoid rim and the glenoid ligament, and a second tear between the inferior

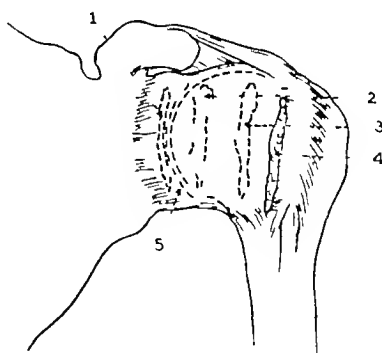


Fig 5 The artist's conception of the tears as viewed extracapsularly in the depth of the wound. The most frequent one is in position 2. Not infrequently the middle glenohumeral ligament traverses this rent, instead of being torn with the capsule. 1, The site of the tear at the glenoid rim, the glenoid ligament going with the capsule. Technically this is the most difficult to repair as there is nothing to sew to except the bony glenoid rim, 3.



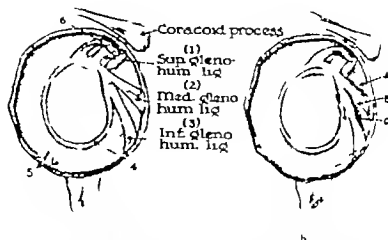


Fig. Looking into the shoulder joint after removal of the head of the humerus from its end of the capsular tube. 4 is the free margin of the capsule (tube); 4 is the end attached to the rim of the glenoid. 4b contains the thickened triangular fibrocartilaginous band known as the glenoid ligament. 1 and 2 represent the articular folds of the thickening in the capsule known as superior, middle and inferior glenohumeral ligaments; 3, intra-articular biceps tendon. b, C, Ties between rim of the glenoid and the glenoid ligament, 4. B, Knt between the middle and inferior glenohumeral ligaments. 4. Knt baseward from the middle glenohumeral ligament.

nary sequel of ordinary traumatic dislocation. That is to say, ordinary dislocation is due to a fall on the abducted or outstretched arm and by deflection against the scromion, the head is forced downward through the capsule and between the subscapularis and triceps muscles. These heal after the dislocation is reduced.

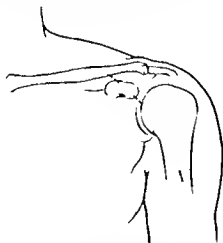


Fig. The incision begins at the coracoid process and is directed toward the external epicondyle. Such is the course of the cephalic vein.

The recurrent type however is due to direct force on the shoulder from behind on the elbow when the latter is directed backward. In this injury then, to quote Bankart, "The head of the humerus is forced out of the joint, not by leverage, but by direct drive from behind forward. In its passage forward the head shears off the fibrous or fibrocartilaginous ligament from its attachment to the bone. The detachment occurs over practically the whole anterior half of the glenoid margin. The reason why the dislocation recurs after reduction is that, whereas a rent in the fibrous capsule heals readily and snugly, there is no tendency whatever for the detached glenoid ligament to reattach itself to the bone. The defect in the joint is, therefore, permanent and the head of the humerus is free to move forward over the anterior margin of the glenoid cavity on the slightest provocation.

#### THE ANATOMY

The shoulder joint is a ball and socket joint. In order that the range of motion might be great the glenoid fossa is quite small as compared to the head of the humerus. Consequently stability depends upon the muscular and capsular structures about the joint. Someone has remarked that the capsule is like a band and thin and is inconsequential as far as stability of the shoulder joint is

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**A**MEBIC infestation of the liver presents important diagnostic and therapeutic peculiarities requiring full recognition if acceptable results are to be obtained. In many surgeons there is still a strong tendency to apply to this disease the principles used in controlling pyogenic processes of bacterial origin because of the frequent similarity in gross features. That such methods are exceedingly inadequate was apparent when it was found in 1931 that the mortality in this disease at the Los Angeles County Hospital was 85 per cent. Significantly, this included a high percentage of cases detected by necropsy and emphasizes that the disease is capable of such protean manifestations that much vigilance is required to secure sufficient diagnostic accuracy to make treatment effective. Since 1931, 74 cases of amebic abscess have been recognized and furnish the basis for this report, in which the diagnostic and therapeutic problems are considered.

## DIAGNOSIS

DIAGNOSIS

Certain general features of the disease always emphasize Amebic infection of the colon always antedates the liver lesion, but many cases of amebic colitis are clinically silent, and the usually conceived picture of amebic dysentery does not exist. Thirty of our cases gave a history of diarrhea and 44 failed to recall diarrhea, while 6 complained of constipation. Therefore in less than half the cases is a diarrhea present to suggest consideration of amebiasis. Gross colon lesions were present in 14 of the 24 cases in which postmortem examinations were made, and in 5 of these there had been no diarrhea. The foregoing emphasizes that the implications of the name 'amebic dysentery' has tended to exclude consideration of amebiasis in a large number of cases, and further that the surgeon must therefore commonly diagnose a complication, amebic hepatic abscess, in the absence of any signs of the primary disease. Whether or not diarrhea is present, the stool usually contains cysts, trophozoites, or both. In 55 cases of this series stool examinations were done with positive findings in 40. Because of the great value of a positive stool examination in the diagnosis of amebic hepatic abscess, stool examination is a part of the routine of the University of Southern California.

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Calif. and  
head before the Western Surgical Association  
resorts December 5, 1941

ination should be done upon the slightest suspicion of the presence of this lesion. Saline catharsis is helpful in raising the incidence of positive stools. Certain standard etiological relationships are developing the diagnosis.

Certain standard etiological relationships are usually considered in developing the diagnosis. In this series there were only 5 women. No patient was under 20 years of age, and the age distribution is relatively even after the thirtieth year. Although alcoholism has been thought to predispose to the development of amebic hepatic abscess, such could not be concluded from our cases. However, a seemingly important relationship does exist between trauma and amebic abscess. In 3 instances the patient was entirely well at the time of a very considerable trauma to the liver region, and immediately developed symptoms subsequently proved to be due to amebic abscess. This has considerable medicolegal significance and also necessitates the inclusion of amebic abscess in the differential diagnosis of the sequelae of liver trauma. Further, this suggests that amebic infestation of the liver is compatible with an absence of any significant lesion, because trauma could only operate by determining the activation of a latent infection.

Turning from the foregoing general implications, the diagnostic problem must be clarified by consideration of the various syndromes presented by patients with amebic hepatic abscess. Incorrect diagnosis accounted for more deaths than occurred in the treated patients in this series, from a hospital quite alert to the presence of the disease. Ten cases were not recognized before necropsy, and an approximately equal number probably existed in deaths in which necropsy was not done. This total would exceed the 16 deaths in our 63 treated patients. This diagnostic difficulty is due to the fact that, at least in Southern California, amebic hepatic abscess presents many manifestations not included in its description in textbooks or in the literature from the Orient. Instead of regularly being chronic in 58 per cent of our cases the process was an acute severe disease. A second important general feature is that instead of the lesion being one which almost exclusively presents in the right upper quadrant, in 53 per cent of our cases abdominal features were absent or minimal and the clinical phenomena were pulmonary, because the abscess was located in the dome of the liver.

tion. The patient was operated upon on February 4, 1941. At operation the capsule showed  $\frac{3}{4}$  inch tear 1 1/2 inches flap still attached to the glenoid margin. This flap was roughened and the capsule was sewed directly into it. The postoperative course since then has been uneventful.

CASE 4. G. K., aged 30 years, injured shoulder 3 years ago in football game when several players fell on his back. His arm was treated by strapping it his side for weeks. Since then it has been dislocated several times especially when held in abduction or hyperextension. The patient was operated upon on January 4, 1941, at operation the capsule showed 1 inch tear about  $\frac{3}{4}$  inch from the glenoid margin. The capsule was sewed into this flap. The postoperative course has been uneventful.

CASE 5. J. J. age 27 years. In May of 1935 the patient suffered an anterior dislocation of the shoulder while under mechanical treatment. From that time until June, 1939, the shoulder dislocated 5 times. Each time the arm was more easily dislocated and reduced. Patient was operated upon on July 3, 1939. A considerable portion of the capsule was destroyed. The capsule was sewed into the glenoid with braided silk. The postoperative course was uneventful. When he was last seen in September 1939, the only disability was slight limitation of abduction and outward rotation.

CASE 6. C. P. aged 30 years. In the fall of 1933, the patient dislocated his left shoulder while playing football. It was reduced by doctor but he had no immobilization. Since then it has dislocated about 5 times. The last time it dislocated was in the fall of 1939-1940 during basketball game. On August 9, 1940, the patient was operated upon. There was rent in the capsule  $\frac{3}{4}$  inches long. The capsule was sutured into the glenoid rim. Postoperative course was uneventful. On December 4, 1940, the patient had good range of motion excepting slight decrease in external rotation. He is now able to play basketball without trouble.

CASE 7. M. L.  $\frac{3}{4}$  years ago dislocated the left shoulder while in scuffle. At the time the arm was reduced by

doctor. Since then he has dislocated the arm several times, once when he was asleep. On March 5, 1941, the patient was operated upon. A 1 inch tear was seen in the capsula. A slight amount of granulation tissue was seen. The capsule was imbricated with silk sutures. The postoperative course was good.

#### SUMMARY

Tears in the capsule of the shoulder joint in the subacromial space can be demonstrated by dissecting room. Their location varies slightly, some being between the middle and lower glenohumeral ligament, some between the glenoid ligament and the rim of the glenoid fossa, a few being humeralward to the inferior glenoid ligament. This pathological picture is constantly found in the so called direct force dislocations of the shoulder joint which is the forerunner of the habitually dislocating shoulder. Repair of the rent has seemed to be a proper indication in treatment for preventing subsequent dislocation.

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tion exposes the heart to lower concentrations of the drug than does intravenous administration

#### RESULTS OF TREATMENT

In our series there are 3 groups of cases, those apparently cured with emetine only, those requiring aspiration in addition to emetine, and those who were treated surgically with or without emetine

*Cases treated with emetine only* When the diagnosis of amebic abscess has been made our patients have been routinely given emetine as described. I frequently a very favorable response occurs, and with continuation of the drug, apparent cure takes place. Nineteen patients were treated in this way with complete recovery in all. The largest total dose of emetine was 16 grains, the average 9.5 grains. The drug was administered intravenously in 10 and intramuscularly in 9. In this group are 4 cases with negative aspirations. We assume that the aspirations were technical failures, but they may represent the supposedly beneficial effects of hepatic phlebotomy. Also there are 3 cases of bronchohepatic fistula. The majority of this entire group were initially clinically indistinguishable from the group requiring aspiration, however, they could have been amebic hepatitis, or cases with a small abscess, or represent infection with very emetine-susceptible strains.

There are other chemotherapeutic aspects to the problem of hepatic amebiasis. In one of the other groups a patient being given emetine deteriorated steadily after liver drainage but improved rapidly when valeren therapy was instituted although there were no colon symptoms. This may be significant in the treatment of "emetine resistant" cases of amebic hepatic abscess. The colon problem is important in two ways. First, the mortality in the group with active colon disease is considerably higher than in the cases with latent colon infection. This indicates the need for active colon therapy in the group with active colon lesions. Second, in all cases the colon infection must later be treated as a part of the program to prevent reactivation of the liver process. This hazard is exemplified in our series by 5 cases in which patients had previously had amebic abscess 1 month, 2 years, 5 years, 9 years, and 13 years, respectively. Part of these may have represented new liver infections while the remainder indicated reactivation of old abscesses. An aid in measuring inactivation of the infection is the blood sedimentation rate, and, used in a small group of this series, it has constituted an important guide in indicating the need of fur-

ther treatment, when on clinical grounds it would have been discontinued. In the 21 cases in which autopsy was carried out the number of abscesses found varied from 1 to 8, all were on the right except in 2 cases with 1 each on the left in addition to the 2 on the right in 1 case and 1 on the right in the other. The diaphragm was perforated in 6 and not perforated in 15. There was a colon lesion in 14 and none in 7. Colon perforation was noted in 3 cases and in 1 of these there was noted also a perforated amebic appendicitis.

*Cases treated with emetine and aspiration* A second group of cases are those in which, after emetine has been started the response is not satisfactory, or a mass exists, or a very large liver. In these aspiration becomes necessary, and it may require repetition. For this procedure a cerebral ventricle needle is an excellent instrument, it is of large bore carries a stylet, and is quite blunt, favoring minimal danger of hemorrhage. The skin and underlying fascia may be nicked with a sharp pointed scalpel to facilitate its passage. If an area of edema or localized tenderness exists, aspiration should be done at that point. If a mass exists, aspiration should be done directly into it. The problem cases are those in which localizing physical signs do not exist, and these are usually dome abscesses. It is usually recommended for such cases that aspiration be done through the tenth intercostal space in the anterior axillary line and that if the needle be passed upward, inward, and backward not more than 3.5 to 4 inches, the great vessels will not be injured. We believe that dome abscesses are readily missed by this technique and prefer to aspirate high along the right costal margin, going upward, outward, and backward. In no case has emetine or lipiodol been injected into the abscess cavity. Routine smears should be made at once to exclude the presence of bacterial infection. In the series herein reported treated by emetine and aspiration there are 18 cases and no deaths. The amount of emetine given varied from 4 to 24 grains, the injection being intravenous in 15 and intramuscular in 3. Three required 3 aspirations and the largest amount aspirated at any one time was 2200 cubic centimeters, the lowest 45 cubic centimeters. Two cases are included in which at the time of laparotomy an abscess was discovered, the abscess was aspirated, and the abdomen was closed without drainage. The question of multiple abscesses requires consideration. In 7 of the 24 autopsies, multiple abscesses were present. In none of the treated cases was more than one recognized. This discrepancy could be explained

Because of these two fundamental variations, four syndromes are seen: an acute costal margin syndrome, a chronic costal margin syndrome, an acute pulmonary and a chronic pulmonary syndrome. Each of the four involves a separate field of differential diagnosis. The chronic syndrome at the costal margin includes the classical cases. These may be misdiagnosed as malignancy of the liver, stomach, gall bladder or colon cirrhosis, amyloid disease, echinococcus cyst, pancreatic cyst, or hepatic lobatum. The acute syndrome at the costal margin is more frequently misdiagnosed, and is usually mistaken for acute cholecystitis or penetrating or perforated duodenal ulcer or abscess complicating either peptic ulcer or cholecystitis. The chronic pulmonary syndrome closely resembles cancer of the lower lobe when chronic pneumonitis exists without pleural effusion, whereas if effusion exists tuberculosis or cancer are usually considered responsible. In the acute pulmonary form basal pneumonia is repeatedly diagnosed and empyema is added when effusion occurs, or an acute pleurisy with effusion is considered to be present. In such cases a bronchial fistula may fortunately occur and the appearance of anchovy sauce sputum develops a correct diagnosis. If the left lobe of the liver be involved by amebic abscess, again the process may be acute or chronic, and the phenomena occur in the epigastrium rather than at the left costal margin and if transphrenic effects appear they are likely to be pericardial. In order to attain any high degree of clinical accuracy amebic hepatic abscess must consistently be added to the possibilities in differential diagnosis in each of the foregoing situations.

A few general diagnostic considerations should be emphasized. Hepatomegaly is a constant feature, often detectable in the bedside examination, and usually demonstrable by roentgenological study. Even with dome abscesses there is often downward enlargement. In the very chronic cases abscess may point and produce mass which can be recognized to be arising from the liver. One of our patients had such a mass for 20 years and the condition simulated very closely echinococcus cyst of the liver.

When the phenomena of amebic abscess are superior instead of anterior, ray study will accurately reveal the phrenic or transphrenic effects. The most characteristic changes are, as emphasized by Ochsner a tergo and medial in the lower right chest. Elevation and immobility of the diaphragm are the earliest findings. Pneumonitis or pleuritis alone or in combination occur as the lesion progresses.

The systemic features are not specific and parallel the extent and acuteness of the liver lesion. Two aspects should be emphasized. First, night sweats are frequent in the chronic cases and should serve to raise doubt if the case has been diagnosed as cirrhosis or carcinoma of the liver. Second, in the acute cases, chills may be so outstanding as to suggest the presence of pythemia or malaria, or if jaundice exists, a cholangitic basis is suspected.

#### TREATMENT

The primary basis for cure of amebic abscess is emetine in sufficient dosage. Amebic abscess is a special type of liver necrosis, as is a gumma, and emetine is approximately as much a specific as neosphenamine. If amebic abscess were looked upon as being similar to a broken down gumma, with aseptic evacuation of its contents often required to eliminate a foreign body factor for proper orientation for treatment would be established. Two factors have tended to confuse the situation: first, the frequent gross resemblance to, or the possible actual presence of bacterial infection, and, second, timidity in administering adequate amounts of emetine.

The resemblance to bacterial infection may be striking. In a third of this series the abscess content was not anchovy sauce pus but rather was creamy white puriform material. In a number of instances it had a very foul odor. Aerobic and anaerobic cultures of this foul material remained sterile. Except in 3 cases in which extensive liver and diaphragm destruction existed, every abscess in our series was sterile, although the incidence of secondarily infected abscesses is given in the literature as 24 per cent.

Hesitation in giving adequate emetine is dependent upon fear of its capacity to injure the myocardium. As a result many patients with amebic abscess of the liver have retained possession of excellent hearts but have died of insufficiently treated amebic abscess. We do not exhibit indifference toward the dangers of emetine but since amebic abscess is a fatal disease, the amebae must be destroyed. Our patients have usually been given 1 grain daily intra-venously or intramuscularly if 6 doses, then a rest for 6 days and the course repeated as necessary. As much as 24 grains have been given in this way and not one cardiac problem has developed. Under extreme conditions the rest period should be lengthened. Electrocardiography in conjunction with close observation of the blood pressure and reactions of the patient are of great help in controlling the therapy. Intramuscular administration



by supposing that, during aspiration of an abscess, the lowered pressure would tend to break down the wall of an adjacent abscess, or that emetine controlled a small second abscess. We probably had no treated cases with widely separated large abscesses.

*Cases treated surgically* The surgically treated group comprises 26 cases, 14 adequately treated with emetine. The mortality was 53 per cent. This group is in no way comparable to the previous group. In 4 there were acute intraperitoneal ruptures, and patients were operated upon for duodenal perforations and 3 survived. If such an abscess is small and has emptied itself drainage is of no value while if it is large and still leaking a short period of drainage is indicated. In 2 cases rib resection was done for secondary infection of the pleura. Of these 2 1 lived and the other died with the empyema practically healed, and at autopsy an active small amebic liver abscess communicating with a bronchus was still present. Many amebas were present even though 16 grains of emetine had been given, probably an emetine resistant strain. Ten of the 19 remaining deaths were in the 10 cases given practically no emetine. One death was due to open drainage with a resultant postoperative bacterial infection of the liver. It may be stated that surgery usually is necessary in 4 situations: for safety in exposing left lobe abscesses, for acute rupture because the

diagnosis cannot be made for pyogenic complications in the pleural cavity and for drainage of amebic abscess complicated by bacterial infection. For the usual case the stress of surgery and the danger of secondary infection combined with the evidence that it is unnecessary should make it reasonable to conclude that the indications for surgery should be confined to those described.

Of the 26 patients operated upon emetine is given varying from 35 grains to .5 grains was given in 19 cases, not given in 7 cases. The intravenous route was used in 0 the intramuscular in 9.

#### CONCLUSIONS

Our conceptions of the foregoing problems have been restricted by the implications in the names "tropical abscess" and "amebic dysentery." The disease is in no way confined to the tropics; the liver lesion is not, in the usual sense, an abscess and "amebic dysentery" actually describes only the severe form of amebic colitis. The resultant restricted conceptions have served as a basis for innumerable diagnostic failures. Realization that amebiasis is endemic in temperate climates, that amebic hepatic abscess is a special type of liver necrosis, for which there is specific chemotherapy, and that amebic colitis is commonly symptomatic, will help in creating more frequent recognition of the presence of the disease and improve the therapy applied.

# METAPLASIA AND CARCINOMA IN CERVICAL POLYPS

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**A** CERVICAL polyp is simply a localized heaping up of normal cervical tissue. It may have a squamous or a columnar epithelial surface and its core may be fibrous tissue (fibrous polyp) or glandular as well (mucous polyp). Although its origin is obscure, inflammatory lesions of the cervix are most frequently the background.

Cervical polyps are usually red, pedunculated, and fragile, and may be the cause of intermenstrual or contact bleeding. According to Israel, 14 per cent of office patients presenting themselves because of irregular bleeding were found to have cervical polyps, whereas 24 per cent of consecutive gynecological patients admitted to the hospital for any cause were found to have polyps. Geiger states the incidence to be 15 per cent of 2,048 patients seen at the Cook County Hospital. The occurrence is placed as high as 10 per cent by Fetterman who studied 1,000 gynecological patients.

There is general agreement that cervical polyps appear most frequently in the fifth decade and in parous women (7). As many as 43 per cent are asymptomatic as far as the polyp itself is concerned. However, it has been noted by many that associated gynecological pathology is very often found.

## SQUAMOUS METAPLASIA

In cervical polyps as well as the cervix, subject as they are to trauma, bleeding and inflammation, squamous metaplasia is a process often seen, sometimes atypical, and not infrequently diagnosed as "precancer" or even cancer, for which extensive therapy is given. Superimposed cancer may be missed when a disorderly, anaplastic and undifferentiated epithelium is ascribed to an inflammatory or metaplastic change. Because inflammation is so frequently associated with squamous metaplasia (or epidermization), cause and effect relationship has naturally been thought to explain the latter. Meyer (9) believes that during inflammation, the columnar epithelium is hyperactive, extends outward to the portio vaginalis where it becomes eroded only to reap-

pear during the first stage of healing when it forms new glands. As the healing continues, the squamous epithelium again asserts itself as metaplasia, pushing the columnar epithelium back to the external os, in a reparative process.

These stages of healing are interchangeable. Meyer explains the finding of metaplasia high in the endocervix or in the endometrium on the basis of squamous epithelial "rests" left stranded as a result of interplay of the stages of healing, and cites evidence that in the 6th month of embryonic life the indifferent squamous epithelium lining the cervical canal is pushed out by the developing columnar epithelium. Novak believes that genuine metaplasia may take place from columnar to squamous epithelium, but not from squamous to columnar. Fluhmann concludes that metaplastic squamous epithelium is derived from infraepithelial indifferent cells which become converted into squamous epithelium as a result of inflammation and crowd out the columnar cells.

That squamous metaplasia is a process frequently encountered is attested to by Fluhmann, who found it in 29 per cent of 100 cervical polyps. Of 1,195 specimens of cervix examined, 59, or 4.9 per cent, were found to have metaplasia. He felt that since metaplasia (or "epidermidalization") is so frequent in polyps and cancer so rare, metaplasia would seldom if ever be the forerunner of cancer. However, certain atypical forms were so disturbing as to make differentiation from cancer quite difficult. In these borderline cases, three principles are of help in making the decision (Schauenstein, Pronai, Rubin, Ewing, Fluhmann, 5).

1 *Atypical properties of individual cells*—dark and dense staining characteristics, irregular nuclei, absence of regular order, atypical and asymmetrical mitoses are properties of malignant neoplasm.

2 *Differentiation of tissue*—In malignant neoplasms, the basal epithelium is irregular in arrangement and the cells lie obliquely or transversely to the surface. In epidermidalization, the cells lie in normal or parallel lines.

3 *Invasive and destructive properties of the proliferating cells* (Although pearls are found in malignant neoplasms, they are not pathognomonic of malignant growth since they are found in normal tissue).

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Presented at the Clinical Congress of the American College of Surgeons, November 6, 1941.



## CANCER

How often does carcinoma arise in cervical polyps? Martzoff has had the same experience as Cullen in not finding a single bona fide instance of a malignant cervical polyp after an extensive study of cancer of the cervix, but presents a very convincing photomicrograph of an early squamous carcinoma *in situ* which he calls "superficial cancer." That this is, indeed, cancer and progresses to invasion and destruction if untreated, has been demonstrated clinically at the Free Hospital for Women (12, 13, 16) where all such lesions (usually found in routine biopsies of Schiller positive areas in the out patient department) are regarded as cancer and treated as such. Meyer has repeatedly called attention to this early malignant lesion (10). Perhaps the failure to recognize this early cancer has led to the popular misconception that any cervical polyp is undoubtedly benign and therefore does not warrant the trouble and expense of pathological examination. As opposed to this point of view is that of Witherspoon who states that 5 per cent of polyps are malignant, and Fetterman who places the incidence as high as 6 per cent in 100 cervical polyps studied. It may be that this high incidence is due to the inclusion of cases of atypical squamous metaplasia as cases of malignant neoplasms. Other estimates as to the incidence of malignant growths in polyps are between those two extremes. Israel has found 1.7 per cent of 117 polyps to be cancerous. Geiger 3.1 per cent of 3. Day 0.33 per cent of 300. Flohmann, 3 per cent of 120 and Condit, 0.5 per cent of 300. Other isolated cases of carcinomatous polyps are reported (2-4).

## CASES AT THE FREE HOSPITAL FOR WOMEN

The recent finding within 5 days of 2 patients having cancer superimposed on an otherwise benign cervical polyp stimulated a study of the microscopic slides in all cases of cervical polyps removed at the Free Hospital for Women. From September 1902 to October 1931 there were slides available in 636 cervical polyps. Of these, 513 or 80.3 per cent, were found to have squamous metaplasia, or epidermalization of glands. This metaplastic process varied from mild to marked degree. Of these 1,636 cases, 5 or 0.37 per cent were found to be complicated by carcinomatous changes. Two were adenocarcinomas, and 3 were squamous carcinomas. Two of these had originally been judged benign; one patient is untraceable and the other is still alive after 1 year. Four of the polyps showing marked typical metaplasia had originally been judged malignant and

all were treated as such, the patients now being alive and well—5, 2½, 2 and 4 years later respectively. It is notable that all 5 carcinomatous polyps are associated with squamous metaplasia and that in 3, the metaplastic epithelium is cancerous. This would tend to show that metaplastic epithelium, though undoubtedly benign (1 out of 3 polyps, roughly showed this change) is not immune to malignant change. The fact that 1 polyp in 315 (5 in 1,636) was malignant would show that the epithelium over cervical polyps, just as over the cervix itself may be the seat of malignant growth. No instance of undoubted sarcoma definitely arising in a cervical polyp was found.

*Squamous Metaplasia in Cervical Polyps*

CASE 1. Mrs. H. No. 5-39-1012, (Fig. 1), 49 year old octipara, on September 2, 1930, had a cervical polypectomy incident to the treatment of prolapse. The polyp had led to no symptoms. Microscopically was seen a cervical polyp with chronically inflamed connective tissue core. The surface squamous epithelium showed keratinization deposition (leucoplakia) in the superficial layers with hyperkeratosis. Near the base of the polyp, the squamous epithelium became metaplastic and provided under the framework of the columnar glandular epithelium here it appeared in patchy distribution. The framework as intact and as the skeleton for the metaplastic epithelium, which grew down regularly along the bases laid down for it by the columnar epithelium.

CASE 2. Mrs. R. N. 8-41-245, (Fig. 2), 30 year old quadripara, complained of dyspareunia flowing for years and prolapse. An incidental polyp, as removed on February 6, 31 and the cervix was excised. An early adenocarcinoma of the endometrium found on curettage required subsequent hysterectomy. The patient is alive and well 8 months later. Microscopically the polyp was the seat of marked chronic inflammation with plasma cells present in abundance. The metaplastic process was more developed here the entire surface being covered by squamous and columnar epithelium. Numerous frigate projections are seen on the surface. Incident to the marked inflammation, the cervical glands had become markedly tortuous and ended in adenomatous configurations. Thus the skeleton as laid down for by original arrangement of metaplastic epithelial proliferation in one area the erosion as not yet covered by epithelium.

CASE 3. Mrs. Mac P. No. 87795, (Fig. 3), 42 year old primipara, had a polypectomy contribution of the cervix and supravaginal hysterectomy for atrophic blennorrhoea on April 3, 1937. She had complained of low abdominal pain, recent menorrhagia, and menorrhagia. She did not return for follow up. Microscopically the cervical polyp showed the original glandular arrangement mostly replaced by metaplastic epithelium which, however still maintained a benign nature. The irregular processes of squamous epithelium intricately arranged were so angry looking because of the adenomatous nature of the original columnar epithelium being undergrown and replaced, but not invaded.

CASE 4. Mrs. S. No. 5692, (Fig. 4), 44 year old septipara, had complained of menorrhagia for 3 months but there had been no intermenstrual bleeding. A small cervical polyp was excised and the cervix was contracted on February 1, 1936. Because the original diagnosis was



Fig 1 Case 1 Cervical polyp with beginning metaplasia  $\times 95$



Fig 2 Case 2 Cervical polyp with squamous metaplasia and "adenoma"  $\times 95$



Fig 3 Case 3 Cervical polyp with marked squamous metaplasia  $\times 95$



Fig 4 Case 4 Cervical polyp with marked atypical metaplasia  $\times 95$

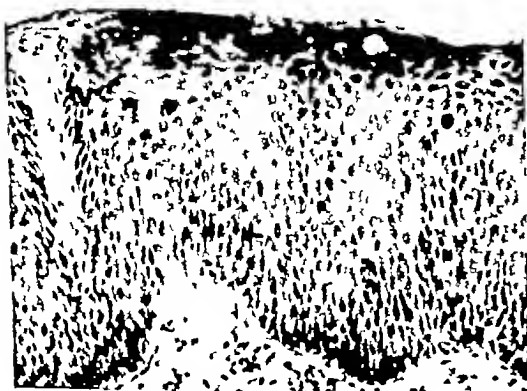


Fig 5 Case 1 Squamous carcinoma in cervical polyp  $\times 185$

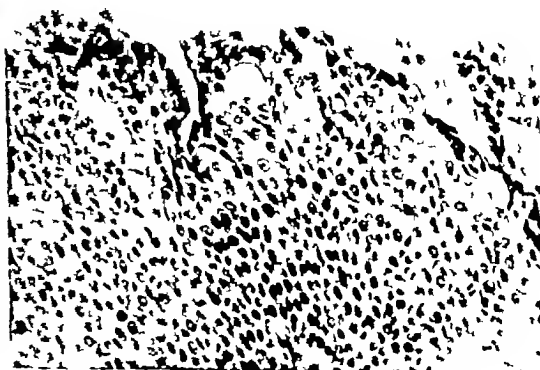


Fig 6 Case B Cervical polyp with squamous carcinoma starting in metaplasia  $\times 185$

that of grade I squamous carcinoma, total of 3,000 milligram hours of radium and 4,000 milligrams of ray as given. The patient as ill and all 5 years later *Microscopically* there as seen cervical polyp in which no glands were left. The squamous metaplastic epithelium had grown exuberantly and even pearls were beginning to make their appearance. Occasional symmetrical nodules are seen in the basal layers. However there as good organization and no anaplasia of the cells. This intricate picture as the end result of marked chronic inflammation with adenomatous formation of cervical glands, moderate growth and final replacement of glandular epithelium with metaplastic epithelium. This polyp as benign.

#### Carcinoma of Cervical Polyp

CASE A. Mrs. Sch. No. 6867, (Fig. 5) 47 year old primipara, as seen in the out patient department on July 8, 1935 because of frequent and prolonged periods for years. A centimeter cervical polyp as excised and reported benign. The patient as still ill after years. *Microscopically* the polyp as covered by columnar epithelium but here and there by metaplastic but malignant squamous epithelium. Which as growing down in processes, infiltrating and destroying the somewhat dilated glands. The cells are dark staining, disorganized, and show of numerous mitoses even in the surface epithelium.

CASE B. Miss B. No. 9495, (Fig. 6) 54 year old, unmarried nullipara, with menopause 7 years before complained of prolapse. On September 29, 1935 a bipectinate asymptomatic 1/2 centimeter polyp as removed and the base as cauterized. The endometrium as atrophic. The polyp as reported as benign. Seven months later the patient is ill and all. She is now untraceable. *Microscopically* the polyp showed moderate evidence of metaplasia. However in one surface area, the metaplastic epithelium was thickened by an exuberant middle layer growth of cells which are undifferentiated, dark staining, and presented innumerable mitotic figures per high power field. There as as yet no invasion.

CASE C. Mrs. M. No. 9564, (Fig. 7 and 8a) 38 year old secundipara, entered the hospital because of periods which come every 2 weeks for 9 months and daily bleeding which had occurred for 3 months. On November 8, 1935, friable cervical polyp in the midst of crumbly cervical tissue as removed. A total of 3,000 milligram hours of radium and 4,000 milligrams of ray as given. The patient as ill and all 1 1/2 years later. *Microscopically* the polyp as covered by malignant squamous epithelium composed of dark staining undifferentiated cells invading the stroma and the neighboring glands. There as variation in size and shape of the nuclei and numerous mitoses are seen. The surrounding cervical tissue as also invaded.

CASE D. Miss St. J. No. 5074, (Fig. 8 and 9a) 49 year old unmarried nullipara entered because of low abdominal pain for 4 years, regular periods, and brown flashes for 4 years, and discharge. On September 9, 1935, centimeter cervical polyp as removed and 3 centimeter pedunculated subcervical fibroid as also removed. *Microscopically* the surface of the polyp as eroded and the stroma as edematous, infiltrated with acute and chronic inflammatory cells. The endocervical glands had lost their mucous secretory acini and are arranged in close association with benign squamous metaplastic epithelium. These glands are intricately arranged in groups and extremely pale up growing in papillary processes into the lumen. The mucous reduplication hyperchromatic nuclei, and frequent mitoses are evidence of malignancy.

On December 9, 1935 complete hysterectomy with bilateral salpingo-oophorectomy as performed. No malignancy as demonstrable in the excised specimen.

CASE E. Mrs. A. No. 8407 (Fig. 9 and 10) 29 year old primipara, entered the hospital because of frequent and prolonged periods for 4 months, with bright red blood for 4 days after each period. A Manchester-Leider operation as done on September 5, 1935, for prolapse and centimeter polyp as removed, together with the cervix. *Microscopically* the polyp shows of squamous metaplasia. However in the of the tortuous endocervical glands, the lining cells are actively growing and invading their mucous secretory acini. Papillary projections are growing into the lumen and down into the surrounding tissue. The nuclei varied in size and shape were hyperchromatic, and showed frequent mitoses some of which are bizarre.

Because the polyp had been attached to the normal cervix, this patient as to be watched closely after further therapy. This time.

#### ANALYSIS OF CASES

Although there 5 cases of carcinoma in cervical polyps vary in age from 38 to 54 years, the average age of 47 years is well in the fifth decade. Two occurred in unmarried nulliparous women, and only one in a patient beyond the menopause. One polyp was entirely incidental, whereas the 4 others were in patients who complained of irregular periods. Intermenstrual bleeding attributable to the polyp was seen in but one patient, who had a fully developed malignant growth. Thus if we are to make an early diagnosis of cervical cancer routine speculum examination of even female patient should be done as well as bimanual examination. A nonbleeding polyp should be excised at the base and the base should be cauterized.

In cases of abnormal bleeding one should not be lulled into a false sense of security by finding and removing a cervical polyp. Simple excision of such a polyp may delay the diagnosis of more sinister coexisting cause of bleeding. Such a patient should have a careful pelvic examination. The cervix should be meticulously examined for suspicious areas often identified by failure to stain with Schiller's solution. If ad haile, therapy should be delayed until the nature of these lesions can be shown macroscopically. Careful curettage of the endocervix and the endometrial cavity should be done to rule out these areas as foci of malignancy.

Polyps should not be thrown into the waste basket but should be studied by the pathologist in every case. If squamous metaplasia is found, there need not be any fear of cancer or precancer.

The incidence of malignancy of 1/3.75 may be low, since once cancer of the cervix is advanced it is impossible to tell whether the cancer started in a polyp or not.



Fig 7 Case C Cervical polyp with squamous carcinoma  $\times 95$

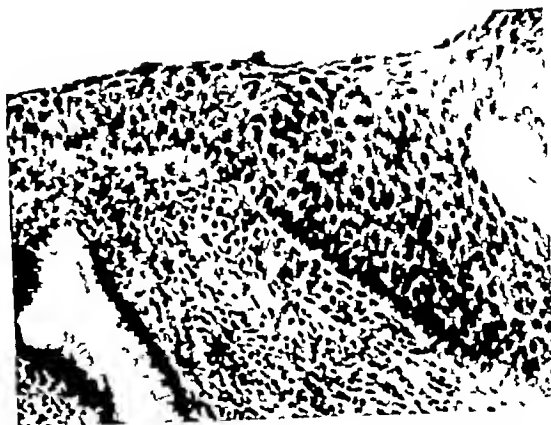


Fig 7a Case C Cervical polyp with squamous carcinoma  $\times 185$



Fig 8 Case D Cervical polyp with adenocarcinoma  $\times 95$



Fig 8a Case D Cervical polyp with adenocarcinoma  $\times 185$



Fig 9 Case L Cervical polyp with adenocarcinoma  $\times 95$



Fig 9a Case L Cervical polyp with adenocarcinoma  $\times 185$

## SUMMARY

1. Cervical polyps are frequently found in gynecological patients.

2. A third of the polyps studied were subject to squamous metaplasia, or epidermization, which is neither a precancerous nor a malignant process.

3. Criteria are cited for the diagnosis between metaplasia and cancer.

4. The development of squamous metaplasia is exemplified.

5. Five cases of carcinoma which arose in cervical polyps are cited among 1,636 polyps studied.

6. Cervical polyps should be removed and their bases cauterized.

7. In cases of abnormal bleeding, their causes should be ruled out by means of careful pelvic examination before the cervical polyp is accepted as the only cause of this bleeding.

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# GRANULOSA CELL TUMORS OF THE OVARY

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THE subject of granulosa cell tumors of the ovary has received a great deal of attention in the literature, especially in the last 10 years. Many very comprehensive reviews of the subject with case reports have appeared. The purpose of this paper is to discern certain features relative to incidence, endocrine influence, histogenesis, and pathology, and to emphasize especially the question of possible malignancy of these tumors. It has been our good fortune to encounter at autopsy a case of granulosa cell carcinoma of the ovary, in which there was metastasis to the gastrointestinal tract. In the American literature, the actual descriptions of metastatic lesions are few. Bell and Datnow present a photomicrograph of a section of metastasis in the omentum from Dodd's case of a granulosa cell carcinoma. The German literature contains several reports of metastatic lesions. Another feature, which is somewhat different in our case, is that death resulted from cardiorenal failure and the granulosa cell tumor was an incidental finding at autopsy. Bland and Goldstein (2), in a review of 311 cases, note that in only 2 was the granulosa cell tumor found at necropsy.

## HISTORY

The history of granulosa cell tumors has been covered very thoroughly in other publications. Robinson states that early descriptions were given by Rokitsansky in 1885 and Acconci in 1888. Usually, as stated by Pratt, von Kahlden is credited with the earliest definite description of the entity. He reported a case of "adenoma of the graafian follicle, with transition to malignancy" in 1895. The name, "granulosa-cell tumor of the ovary," was first used by von Werdt in 1914. R. Meyer followed with publications in 1915. He has subsequently done much towards clarifying the subject.

## OCCURRENCE

In 1939, Dockerty and MacCarty noted that there had been approximately 300 cases of granulosa cell tumors reported. In the American literature, however, until 1930, there had been only 3 cases reported (30). Bland and Goldstein (2) collected 311 cases, which they used as a basis for

their paper. Other series often referred to are those of Novak and Brawner (18), Te Linde, Daily, Meyer, Schulze, Klasten, Szathmary (quoted from Thornton), Habbe, Lepper, Baker and Vaux, and Wolfe and Kaminester (34). As will be noted, many of these are German authors. It is, therefore, obvious that while the German literature contains numerous case reports, the number of cases in the American literature is relatively few. It is no longer believed that granulosa cell tumors are a rarity, but they are infrequent enough and the details of the pathology concerned are sufficiently clouded to warrant other reports and closer attention.

## PATHOLOGICAL PHYSIOLOGY

One of the features of granulosa cell tumors that has aroused most interest is their endocrine aspect. The endocrine significance of these tumors has been discussed, according to Butterworth, by Schroeder, Neumann, and R. Meyer. Meyer states that cells of a new-growth may exhibit a specific functional capacity corresponding exactly to the function of the tissue from which they arise. Thus ovarian neoplasms may functionate and participate in the process of development of secondary sex characters. The hormone produced is "folliculin" or the estrogenic hormone. In a case of granulosa cell tumor in a woman 9 years past the menopause, Schuschania made quantitative estimations of folliculin. During a 5 day period before operation for removal of the tumor, there were 326 mouse units of folliculin in the urine and 619 mouse units in the feces. In the 8 days following operation, there were only 158 mouse units of folliculin in the urine. Sixty-six days after operation, no folliculin was demonstrable in urine or feces. Palmer also made determinations of the excretion of estrogenic hormone by a patient with granulosa cell tumor. He found that the amount of the hormone excreted daily by this patient was about four to five times the average daily excretion by normal non-pregnant women, and about equal to the amount excreted daily by a woman 6 to 8 weeks pregnant. However, a normal woman may excrete more estrogenic hormone in a single 24 hour period during the peak of hormone excretion (the mid-intermenstrum) than was excreted daily by this patient with the granulosa cell tumor. But this

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patient was bleeding while excreting the hormone, and, normally, estrogen excretion is lowest at the menses. Palmer also found that the tumor in his case contained 17 milligrams of estrogenic hormone per kilogram of desiccated tumor. After operation, hormone excretion became normal. He further suggests that some of the hormone may be lost in the vaginal bleeding and, therefore, the excretion of hormone by the kidney will be diminished in these cases. Bland and Goldstein (3) report a very interesting case of a 7 year old girl. This child showed precocious puberty. She was operated upon and a granulosa cell tumor of the left ovary was removed. Eighteen months later she returned to the hospital and a second laparotomy disclosed a granulosa cell tumor of the right ovary which was removed. Before each operation, there were large quantities of estrogenic hormone in the blood and urine, which disappeared after operation. Six months after the second operation the estrin pregnancy test of blood and urine was negative. Frank has done considerable work in the biological significance of ovarian growths in children. The test used by him for determining the estrogenic hormone content of blood requires 40 cubic centimeters of blood. This, as he states, is too large an amount for children. Therefore, in children, female sex hormone tests should be done on urine.

Even very tiny tumors are capable of evoking profound body changes, as noted by Novak (7). With their production of folliculin, the features usually noted are those of effects of excess of this hormone. I.e. precocious puberty, return of vaginal bleeding after menopause, menstrual disturbances in active sex life, hyperplastic proliferative endometrium, possible breast changes. Bleeding may be quite regular (7) suggesting that insofar as mere periodic bleeding of the menstrual cycle is concerned, folliculin plays the all-important role, being possibly an automatic and self regulating mechanism with pituitary interrelation.

Countess, Powell and Black, and others have reported cases of granulosa cell tumors in which within 6 months to a year after removal of the tumors, pregnancy developed. This supports the belief that there is a rapid return to normal of the hormonal and reproductive system following removal of these tumors. As Countess states also, it suggests that large doses of estrin over long periods of time should produce no permanent ill effects on the reproductive system.

Besides the aspects of estrogenic hormone production in these cases, there are apparently other biological effects. The Aschheim-Zondek test has

been positive in a number of instances. Bland and Goldstein (2) suggest that this is evidence of compensatory effort of the anterior pituitary gland to counterbalance the ovarian activity. Some of these tumors may also produce progesterone. These features have not been adequately studied and need more attention.

Thus, the endocrine aspect of granulosa cell tumors is of importance from the standpoint of the tumors themselves, and also because an opportunity is afforded for further study of the effects of certain hormones and the interrelationship of the endocrine system as a whole.

#### PATHOLOGY

**Incidence.** In the series of Sutherland there were 0.9 per cent granulosa cell tumors in 114 ovarian tumors. In Klaiten's series, the incidence was 4.04 per cent, and in Favret's, 1.4 per cent. Thus, taking these together there were 11 per cent granulosa cell tumors in a group of 715 ovarian tumors. Schulze found 4 cases among 43 ovarian carcinomas occurring in 7,500 gynecological cases over a period of 9 years. Thomson states that granulosa cell tumors constitute from 8 to 10 per cent of all ovarian carcinomas. The age incidence has been given by Dockerty and MacCarthy as 60 per cent occurring after the menopause, 30 per cent between puberty and the climacterium, and 5 to 10 per cent before adolescence. T. Linde states that the average age is 5 years, and that 75 per cent occur after the age of 45 years. According to R. Meyer they are most frequent women from 60 to 74 years of age. Fabry in an analysis of 937 cases of post menopausal hemorrhage, found 32 cases of malignant ovarian neoplasms among which there were only 3 granulosa cell tumors.

#### HISTIOGENESIS

There are two main theories as to the origin of these tumors.

The first theory is that of R. Meyer that granulosa cell tumors arise from embryonic cell rests located in the medulla of the ovary. Meyer states that granulosa cell tumors arise from unused embryonic granulosa cells in the medulla of the ovary. Masses of these cells are found in the ovary of every full term fetus. Such masses of cells have also been found in the ovaries of adults. These unused cells may remain in their undifferentiated state which is characteristic for the embryonic ovary. Seemingly they can persist without further differentiation late into life. Therefore, based on the assumption that, under certain, still unknown conditions they might at any stage

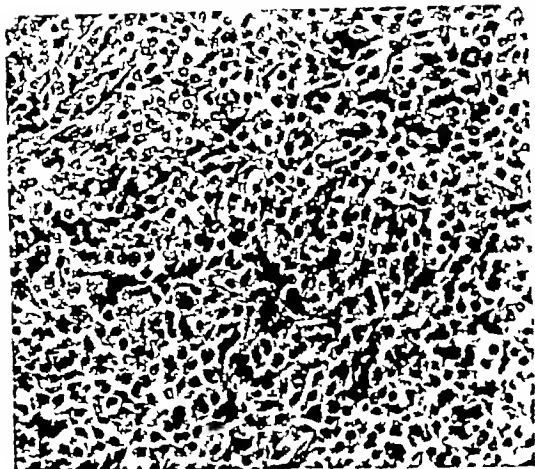


Fig 1 Photomicrograph of section of a primary tumor in ovary showing diffuse arrangement of granulosa cells  $\times 135$

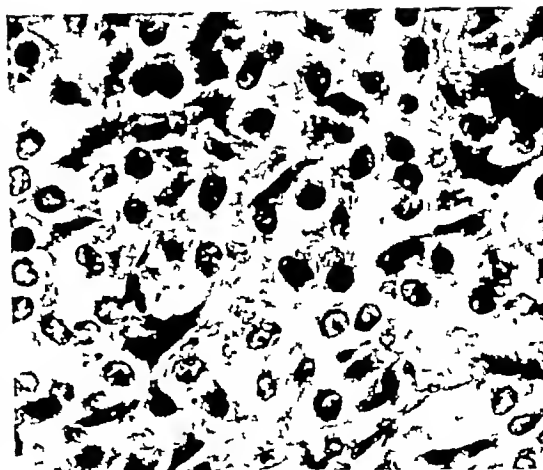


Fig 2 Photomicrograph of primary tumor in ovary showing marked anaplasia of cells and hyperchromatic structure of nuclei  $\times 270$

in children or in elderly women be able to produce granulosa cell tumors. Meyer records having found proliferations of granulosa cells in the medulla of the ovary of a 40 year old woman. Te Linde also had a case in which there was an extremely early but completely formed granulosa cell tumor, situated in the medulla, near the hilum. In adult life, the follicles are limited to the ovarian cortex. Therefore, the origin of this very early granulosa tumor in the medulla practically excludes an adult follicle as its origin. In the medulla, there is much ovarian parenchyme which degenerates more or less completely before birth. By virtue of the position of this small tumor, then, it would seem that embryonal rests of this epithelium, very closely related to adult granulosa epithelium would be practically the only possible origin of this granulosa tumor in the ovarian medulla.

Schiller considers that granulosa cell tumors develop from relics of the normal mesenchymal core of the ovary. This infers, he says, that in the embryogenesis of the ovary, parenchymal remnants which did not enter into any relation with the ovulum, were left there. Years later, due to an unspecific stimulus, the inherent tendency of these cells to form female germ cords shows itself. Then there is first a cellular parenchymal proliferation, forming trabeculae. Eventually, ripe trabecular forms are noted. Finally, there appear follicle vacuoles, filled with liquid, but no ova (Call-Exner bodies). Schiller also points out the fact that granulosa cell tumors occur frequently in old women, this is evidence against the conception of

the development of granulosa cell tumors from the granulosa of mature follicles—elderly women after the climacterium do not have any follicles and consequently no granulosa.

According to Novak and Brawner (18), granulosa cells are formed *in loco* from the ovarian mesenchyme from which likewise is formed the thecal and stromal tissue of the ovary. As they point out, this offers an adequate explanation of the apparent intermutability of the ovarian epithelium and connective tissue and of the frequent transitions between the two in granulosa cell tumors. Thus, the finding of sarcoma-like areas in a granulosa cell tumor is easy to understand. Furthermore, since granulosa and stromal elements are both derived from the same parent tissue, they may have the same physiological capacity to produce the female sex hormone. Thus, even an apparent sarcoma can exert biological influences no less potent than an epithelial tumor of the same histogenesis.

This theory of origin from embryonal cell rests is also supported by Wolfe and Kaminester (34) and Schulze.

The case report by Voight is of interest from the standpoint of histogenesis. In this case, there was a large granulosa cell tumor of retroperitoneal origin with development into the mesosigmoidum. He states that this case supports Fischel's mesenchymal theory of granulosa cell origin. The cases of Ragins and Frankel and of Powell and Black of intraligamentous granulosa cell tumors are somewhat similar. Compton reports a case of granulosa cell tumor of the left ovary, with the





Fig. 3 Photomicrograph of section of ovary illustrating typical follicle forms.  $\times 35$

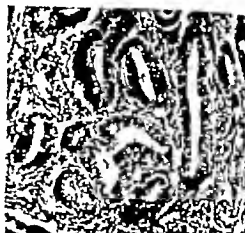


Fig. 4 Photomicrograph of endometrium showing the structure in persistent proliferative phase with marked thickening.  $\times 35$

occurrence 16 years later in the same patient of another granulosa cell tumor in the right vesicouterine fold which was not connected with the right ovary.

As quoted from Powell and Black, Fischel states that germ cells originate in the ectoderm and migrate into the mesenchymal zone of the germinal ridge where the surrounding mesenchymal cells differentiate to form primordial follicles. According to Fischel's concept, the power of forming an organ (ovary) is originally possessed by the mesenchymal cells in a large area which is gradually restricted to a narrower field, which in turn ultimately becomes the gonad. However the mesenchymal cells beyond this field retain a potentiality for differentiation, if stimulated to development. Variation in histological structure in granulosa cell tumors is probably dependent upon the stage of differentiation in the tumor cells toward the adult granulosa cell form. This explains why in the words of Schiller "the tumors when unripe have the character of connective tissue and when ripe show epithelial structure." Thus, undifferentiated but potentially specific granulosa cells may remain in the territory originally occupied by the genital fold. In the adult, this zone extends retroperitoneally from the region of the adrenal to the cortex of the ovary. It is in this area that extraovarian granulosa cell tumors may be expected to occur.

All of the foregoing statements and case reports then, are in support of the theory of embryonic cell rests or ovarian mesenchyme as the origin of these tumors.

2. The second theory that of Robinson, claims that primary ovarian cancers (in which he includes granulosa cell tumor) arise from epithelial elements which constitute part of the fully formed sex gland, i.e. from the granulosa of the graafian follicles. It presents histopathological evidence which are stated to show the gradual transition of granulosa cells of a graafian follicle to a fully formed granulosa cell tumor.

In support of this theory Butternorth has made observations on the histogenesis of ovarian tumors produced in mice by x-rays. After irradiation the ova and many of the large follicles degenerated and disappeared. Smaller follicles, however, apparently were not affected. These nests of cells seemed to increase slowly in size. Eventually they proliferated more rapidly and included the surrounding stroma, forming granulosa cell tumors. This, then, is direct observation of an experimental production of granulosa cell tumors.

The majority of opinion, however, is in favor of the embryonic cell origin of these tumors.

#### MORBID ANATOMY

The descriptions of the gross and microscopic appearance of granulosa cell tumors are numerous. According to Dockerty and MacCarty 90 per cent are unilateral and 90 per cent are solid. They vary in size from pin head nodules to the large retroperitoneal tumors reported by Knight and the 34 pound tumor described by Te Lade. Grossly they usually appear well encapsulated. They are smooth firm, and not adherent to the

surrounding structures. On cut section, they may be partly solid and partly cystic. The cut surface may be bright yellow similar to a corpus luteum or it may have a fleshy appearance like sarcoma. Microscopically, three types are usually described: folliculoid, cylindroid, and diffuse. The folliculoid form appears most differentiated and most closely resembles adult granulosa cells, with follicle formations. The cylindroid type is somewhat less well differentiated, the tumor cells appearing in columns or strands, between the surrounding fibrous stroma. The diffuse form is the least differentiated and is the most difficult to distinguish from a malignant ovarian neoplasm of other origin. It is usual to find areas which are more or less characteristic of any or all of these types in the same tumor. This is in accord with Robinson's statement that these tumors in the course of their evolution present different phases of growth which are not entitled to separate classifications. The so called "types" then are only various phases of a single tumor.

Pratt, in an excellent article on this subject, gives a more complete description of the morbid anatomy of granulosa cell tumors.

#### QUESTION OF MALIGNANCY

This is the phase of the subject in which we are most interested, because we believe our case is definitely a representative of the malignant granulosa cell tumor. Dockerty and MacCarty consider that 90 per cent are of a relatively low grade of malignancy. On the other hand, Novak and Brawner (18) state that "the degree of malignancy is considerably greater than we would gather from most authors, many of whom speak of these tumors as relatively benign." They were of the opinion that 9 of their 33 cases showed unmistakable evidence of malignancy, on the basis of the picture at operation and recurrence. This would put the clinical malignancy rate at 28 per cent. Te Linde states that the majority of these tumors are relatively benign but malignant forms occur (5 to 10 per cent).

The diagnosis of malignancy may be suggested by the microscopic picture, by the fact that recurrences are found, and by the demonstration of actual metastases.

Structurally, these tumors occupy a middle position as to malignancy. They are usually well encapsulated grossly and are nonadherent. Microscopically, however, the cells may be found invading the rather dense capsule and mitoses may be fairly numerous. Te Linde found mitoses most often in the small tumors, which therefore appeared more active than the large ones in which

there was more fibrosis and degeneration. Pratt states that, when malignant, they are more often bilateral. Other authors do not make this statement. They must be differentiated from other types of primary or secondary ovarian carcinomas. It may be, as Pratt says, that the differential diagnosis of malignant granulosa cell tumors will eventually depend upon whether or not the hormone estrin can be elaborated by the malignant tumor cells. That malignant tumors of endocrine glands may be able to produce hormones which are the same as, or comparable to, those formed by the normal gland is suggested by cases of carcinoma of the thyroid gland with hyperthyroidism (Eiselberg). Also, according to Bard's dictum, as quoted by Schattenberg and Harris, it is stated that certain tumors continue to produce the physiological secretions of the parent tissues from which they arose. We believe that our case also supports this contention, as will be seen later.

Schiller is in favor of a guarded diagnosis of malignant granulosa cell tumor on the basis of histological structure alone, since differentiation from other malignant ovarian tumors is difficult.

Robinson presents 4 points of difference from other carcinomas of the ovary: (a) uniformity of the proliferating epithelium, especially early, (b) absence of mitoses with rare exception, (c) absence of infiltrative and destructive tendencies, (d) spread of the tumor by continuity and extension, not by the lymph or blood streams. We cannot agree with all of these statements. It is clear, however, that the microscopic picture is certainly not one which allows for a positive diagnosis of malignancy.

Recurrences are more tangible, clinical evidence of possible malignancy. Various figures are given as to the rate of recurrence. Instances of recurrence are reported by Rummeld, Bland and Goldstein (3), Klasten, and Szathmary. According to the latter two, recurrences occurred in 5 per cent and 10 per cent of cases, respectively. In the cases of Rummeld and of Bland and Goldstein (both in children), no recurrence took place after the second removal. Schiller suggests that these "nonmalignant recurrences" are to be regarded rather as newly formed and independent tumors of the same type as the primary tumor.

The reports of descriptions of actual metastases are not numerous. Of Klasten's 80 cases, 75 per cent were "inoperable" when first seen. The usual sites for metastases are peritoneum, omentum, and broad ligament. Bell and Datnow present a photomicrograph of a metastatic area in the omentum from Dodd's case of granulosa cell

tumor. The ovaries were not removed in this case however. Another of their patients died of "general peritoneal dissemination"—no further description is given. In still another of their cases, military metastases were found scattered throughout the body and cervix of the uterus.

Metastases may also be to more distant structures. Soltmann reported a case of bilateral granulosa cell tumor of the ovaries in a 4 year old woman, who died of an ileus 10 days after the removal of the tumors. At autopsy metastases to the first and second sacral vertebrae were found. Klaffen encountered a case of a 9 year old patient who died 1 year after operation with metastasis in the brain.

One other feature concerning metastases is that they may occur very late, i. e. 3 to 21 years after removal of the primary tumor (Kleins). Klaffen suggests, therefore, that the primary tumor inhibits the formation of distant metastases in the same manner as mature follicles and corpora lutea appear to inhibit the maturation of other follicles in a normal ovary. It is obvious, then, that these cases must be observed over long periods of time before a statement as to absence of metastases can be made with certainty.

#### CASE REPORT

Our case is one of a 64 year old white female who was admitted to the Charity Hospital on October 6, 1931, in a semiconscious condition. During the previous night, she had apparently suffered from a stroke. She is known hypertensive of some duration. A history referable to the possible occurrence of agonal bleeding, etc., is obtainable. On physical examination, the blood pressure was 160/90. She was well developed, well nourished, white female, appeared to be about 65 years of age. She was in a semiconscious state. Pupils were small and fixed. Breasts were atrophic. The heart was enlarged to the left. Systolic thrill was present over the precordium and systolic murmur was heard here. Rales are present in both lung bases and the liver edge is palpable. A small amount of fluid was thought to be present in the abdomen. Pitting edema of both lower extremities was noted. There was flaccid paralysis of the entire left side of the body. She was in a moribund state, and died 48 hours after her admission to the hospital.

The clinical diagnosis was (1) hypertensive cardiovascular disease; (2) cerebrovascular accident.

Necropsy as performed. The peritoneal cavity contained about 500 cubic centimeters of clear serous fluid. About 300 cubic centimeters of slightly purgous fluid was present in each pleural cavity. The heart weighed 60 grams. There are only clumps for the aortic valve, both showing marked calcification. The lungs were congested. The spleen and liver revealed evidence of passive congestion. On the ileum, about 4 feet from the ileocecal valve, there is a white, firm plaque which measured approximately 2 centimeters in diameter. Other smaller grayish white areas are seen on the serosal surface of the terminal ileum. These ranged approximately 1 millimeter in diameter. The adrenal glands showed no gross evidence of pathology. The kidneys are small, pale, and granular. A

few infarcts measuring to 2.5 centimeters in diameter are present in the right kidney. This kidney was fairly movable, being poorly attached to the posterior body wall.

The uterus did not appear enlarged. It measured approximately 8 by 3 by 5 centimeters. On cut section, the endometrium is about 1 centimeter thick. The endometrium was yellow to purple in color and showed velvety appearance. A polypoid structure, measuring 1 centimeter in diameter, as attached to the endometrium in the fundus. A smaller polyp as attached to the endometrium in the midportion of the body of the uterus. The fallopian tubes are of normal length but the diameter was increased. They each measured 5 centimeters by 3 millimeters. The right ovary is slightly larger than the left. The right ovary measured 3.5 by 2.5 by 1 centimeter. The left ovary measured 2.5 by 1.5 by 1 centimeter. On cut section, there was noted in the right ovary a firm, round, yellow structure, measuring 4 centimeters in diameter. Corpora albicantia were present in both ovaries. The cut surface of the left ovary showed nothing of significance.

The brain showed evidence of edema and congestion. The pituitary gland was not enlarged. Its cut surface showed nothing of note. The liver presented no gross abnormalities.

On microscopic examination, the kidneys showed evidence of both chronic glomerulonephritis and nephrosclerosis. There was calcification of some of the smaller vessels in the kidneys. The liver showed an increased amount of fibrous tissue in the portal spaces and the evidence of passive congestion. There was hypertrophy of the heart muscle. Serial sections of both adrenal glands were studied, but revealed no evidence of tumor growth or other pathology.

The sections of the yellow nodule of the right ovary (Figs. 1 and 2) presented distinctive tumor, composed of many rather large cells. These cells showed only slight tendency to form "rosettes." Only few mitoses were noted. Many of the nuclei contained dark eccentric nucleoli. These tumor cells are surrounded by rather dense areas of fibrous tissue, but, nevertheless, appeared to be invading this capsule.

Sections through the largest nodule on the dress showed many collections of the same type of cells noted in the tumor of the right ovary. Here, however, the cells showed very definite tendency to be grouped into "rosettes" and appeared to be attempting to form small lobules—Collier bodies—(Fig. 3). These collections of cells were most prominent in the subcapsular and subserosal layers, but are present in all coats of the testis in the area. The masses here were necrotic, no nuclei being present.

In the section of uterus, the myometrium was thickened with hypertrophy of the individual fibers. The endometrium (Fig. 4) was also thickened and showed an appearance which is quite typical of the fibrous tissue pattern. The sections of the left ovary show nothing of note.

The pathological diagnosis was (1) chronic glomerulonephritis and nephrosclerosis, (2) hypertrophy and dilation of the heart, (3) cerebral edema, (4) malignant granulosa cell tumor of right ovary with metastases to the terminal ileum, (5) generalized arteriosclerosis.

We believe, of course, that the granulosa cell tumor in this case was an incidental finding, the cause of death probably being a combination of cerebral edema and cardiac decompensation. The diagnosis of granulosa cell tumor in this case is based upon the gross and histological structure and upon the finding of a hyperplastic, proliferative endometrium in a senile woman. That the

# HARRIS GRANULOSA CELL TUMORS OF THE OVARY

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tumor was malignant is shown by the metastatic area in the ileum, and by the mitoses, anaplasia of cells, lack of differentiation and tendency to invasion seen histologically

Probably the feature of greatest singularity in this case is the degree of differentiation of the cells in the metastatic area. Here, the resemblance to a well differentiated folliculoid granulosa cell tumor is much more pronounced than in the rather diffuse, anaplastic pattern of the primary tumor. No similar description was encountered in the literature, although the metastatic lesion in the omentum presented in the photomicrograph by Bell and Datnow does show a fairly well defined folliculoid structure. The ovaries were not removed in their case, however, and therefore the primary tumor is not described. Our report presents only a single case and therefore no definite conclusions can be drawn. However, a more highly differentiated histological pattern in the metastatic lesion than in the primary site suggests an explanation for the appearance of late metastases, such as were noted by Klapfen (3 to 21 years). Being well differentiated, they are slow growing and, therefore, take a long time to become manifest. Another point which might be mentioned is that, since the cells in the metastatic area were more differentiated than those in the primary site, they are more likely to have had greater potentiality for hormone production. For those who object to conceding the capability of hormone production to a malignant granulosa cell tumor, there is offered an explanation whereby the more differentiated, and presumably the more benign metastatic lesion may be responsible for a hyperplastic proliferative endometrium in our case of a senile woman is rather definite and conclusive evidence of endocrine activity of the tumor. No normal follicular structures were seen in the otherwise senile, sclerotic ovaries.

Thus, this case appears to be one of definite malignancy in a granulosa cell tumor, which shows the special feature of marked differentiation or "reversion to type" in its metastatic site

## SUMMARY

- 1 The subject of granulosa cell tumors is discussed from the standpoint of history, occurrence, pathological physiology, histogenesis, and morbid anatomy
- 2 The question of malignancy of these tumors is considered

3 A case is presented in which a granulosa cell tumor of the right ovary with metastases to the terminal ileum was found at autopsy. There was evidence of endocrine activity, as manifested by the hyperplastic proliferative endometrium. The metastatic site showed an unusual feature in its marked degree of differentiation

NOTE: A report by McCartney of another malignant granulosa cell tumor of the ovary has recently been called to our attention. In this case, at autopsy, there was seeding on the peritoneum and in the mesentery, and metastatic lesions in the mesenteric lymph nodes and brain. The patient was a 59 year old white female. McCartney, J S, Jr Arch Path, 1940, 29 263-270

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# EXPERIENCE WITH 105 LEG LENGTHENING OPERATIONS

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LEG lengthening operations have been done in sufficient numbers that their indications, value, and shortcomings may be well understood. During the past 12 years we have done 105 such operations. These patients have been continuously followed and the end-results in over 80 per cent of the cases were available for critical analysis. The size of the series and the duration of the observation should make our experience worthy of report.

The original Abbott technique and apparatus have been used exclusively. While Abbott later reported an ingenious new technique based on more rational anatomical considerations, we have not adopted it. This is because it seemed to be rather radical with two extensive operations following closely together and because the original technique had given us satisfactory results. The only modification in our apparatus is that all four pins fit into a slot so that each pin may be independently manipulated when necessary to control bowing of the fragments. In most of our later cases we have used extraperosteal dissection of the tibia, but our experience with this has not yet been complete enough to appraise its value in contrast to the subperiosteal approach.

The operation was most frequently done for shortening due to anterior poliomyelitis. It has also been done for a number of other conditions as will be noted from the table.

*Relation to other reconstruction surgery.* The poliomyelitis patient presents more of a surgical problem than other patients who face leg equalization surgery. This is because several other operations may be necessary or may have already been done. The sequence of the various surgical procedures is important.

If as occasionally happens, the patient arrives a number of years after his illness and has had no surgery on the lower extremity leg lengthening generally speaking should be the first step. Because of the tendency to bowing of the tibia and foot deformities, leg lengthening should preferably be done before any osteotomy to correct leg alignment, tarsal arthrodesis, or muscle transplant below the knee.

On the other hand, certain types of surgery should precede the leg lengthening operation. For

From the Clinics of the Orthopaedic Hospital.

example, hip contractures, hips arthrodesed in undesirable attitudes and unstable dislocated hips require attention prior to leg lengthening. Until the hip has been put in its permanent optimum position it is not possible to determine the acetabular length.

*At what age should the short leg be lengthened?* It was formerly our impression that once the legs of an anterior poliomyelitis patient were made equal they would so remain. Others have been of the same impression. This idea was based on the theory that the discrepancy in leg length was initiated during the acute and convalescent stages of the disease and was perpetuated and exaggerated by the unequal thrust on the two legs incident to weight bearing. We do not believe this to be entirely true and are of the opinion that the main factor is the paralysis itself with the generalized atrophic changes incident to it. At first we lengthened legs of many patients between the ages of 1 and 2. After the operation the legs apparently kept pace for a time, possibly due to the temporary stimulus of the surgical trauma or because the lower extremities were then in a period of relatively inactive growth. However as these patients were followed through their growth period, we found that many of these legs dropped back from  $1\frac{1}{2}$  to  $1\frac{3}{4}$  inches. The discrepancy was more marked in the younger patients with the more severe paralysis.

Legs that are lengthened before the end of growth, when the shortness is due to epiphyseal destruction as with tuberculosis, osteomyelitis, and fractures, obviously will not keep up with the normal leg.

The congenital short leg of  $1\frac{1}{2}$  to  $1\frac{3}{4}$  inches, once equalized, continued to maintain equality as did one case of congenital spastic monoplegia. The ages of the patients at surgery were 10, 11, 12, 4, and 6 years. All were observed to the conclusion of their growth without relative change in leg lengths.

From our experience we believe that leg lengthening should not be done until the period of rapid extremity growth is over. There are exceptions, however, and it is good psychology to remove the stigma of the ugly railed shoe as early in life as is feasible. Given a paralytic short leg in which the shortening is already as great or greater than

# BROCKWAY, FOWLER LEG LENGTHENING OPERATIONS

one could reasonably expect to overcome by leg lengthening, there is no point in waiting and this for several reasons. This patient often needs other surgery which preferably follows the leg lengthening operation. Also the younger patients better tolerate the stretching of soft tissues and osteogenesis is more efficient. Legs in which the shortening is not due to paralysis may be lengthened at a comparatively early age. If the cause is related to epiphyseal destruction the lengthening must be accompanied by appropriate epiphyseodesis in the long leg.

*How much should the short leg be lengthened?* To determine the shortening we measure the legs with a tape and by leveling the pelvis with a raise. Finally the clinically leveled pelvis is checked by a standing x-ray film. Pelvic obliquity, the relation of the femur to the pelvis, leg malalignment and fixed equinus deformity of the foot may make these measurements misleading. It is surprising how much functional length the equinus deformity of an astraglectomized foot adds to the leg. If it requires 2 inches under the heel of a male patient to permit weight bearing on both the heel and metatarsal heads, then this deformity adds 1 inch of functional length if the patient wears a 1 inch heel. With women wearing a higher heel the added length is less. A trial with a raised shoe determines the optimum lengths needed is always preferable and is mandatory when hip function is impaired.

In cases of anterior poliomyelitis, the two legs should not usually be made the same length. How much shorter the short leg should remain will depend upon the severity and the location of the paralysis. With a weak hip and knee it is better to leave the leg about  $\frac{1}{2}$  inch short. When the paralysis is confined to the foot and ankle the legs may be equalized.

When there exists a fixed scoliosis, leveling the pelvis may aggravate the curvature and cause pain. In instances of this sort, as in cases of fused or unstable hips, it is imperative that, before surgery, performance with a shoe raise be studied.

*Tibial versus femoral lengthening.* Lengthening below the knee has been the preference of most surgeons and in our series only 9 lengthenings were done in the femur. Six of these were classified as poor results constituting almost half of our total of poor results. In our limited experience with femoral lengthening we have found the bone fragments harder to control, union slower, and the knee joint difficult to mobilize because of the traumatic arthritis in the joint itself and to adhesions in the extensor apparatus. Immobilization in a spica cast is much more confining than the long

leg cast necessary when the lengthening is done below the knee.

*The patient's viewpoint.* It has been our policy not to bring pressure to bear on the patient confronted with the possibility of leg lengthening. When such an operation seemed advisable, the operation was explained to the parents and the patient, and the final decision was made by them. It is interesting that a large number of patients came in voluntarily and asked to have the surgery done after talking with others who had already gone through with it.

This fact indicates how strongly most patients feel the stigma of wearing a heavy raised unsightly shoe. Not only is such a shoe a never ending source of expense, a dead useless weight attached to the end of a weak leg but even more important, and something some surgeons do not sufficiently realize, it is the badge of the cripple and the psychic trauma it must cause is evidenced by the fact that so many ask to have the operation performed, even though they know that such treatment requires weeks of hospital care and months before the leg is well and strong.

## RESULTS

In 65 per cent of the cases the results were excellent.

In 22 per cent of the cases the results were good in that the preplanned length was obtained with an ultimate strong, useful limb. In this group were delayed unions, long continued drainage with or without sequestration, bowing of the tibia, foot and knee deformities. Likewise included are cases in which the leg lengths were equalized but did not so remain.

In 13 per cent the results were poor in that the length obtained was inadequate or that the patients had residual deformities not readily amenable to treatment.

In the average case (excluding 7 in which no length was obtained) lengthening was started on the fifth day and continued at the rate of 1 to  $1\frac{1}{2}$  millimeters per day until the preplanned length was obtained. A long leg cast was applied at 11 weeks after operation and the pins were usually removed. Plaster fixation was discontinued 24 weeks following surgery, and at the end of 89 months weight bearing without support was begun. This meant that there was generally noted x-ray roentgenographic evidence of union prior to this. There was no appreciable difference in length obtained between the paralyzed and non-paralyzed legs.

Bony union was complete in 30 months in 100 per cent of the cases, 24 months in 96 per cent of

TABLE I.—LEG LENGTHENING OPERATIONS<sup>1</sup>

	Operations
Dislocation congenital hip	7
Dislocation traumatic hip (epiphyseal injury)	
Purulent arthritis hip	4
Fracture femur	
Fracture hip with malunion	
Fracture tibial epiphyseal	
Hemiparesis	4
Osteochondritis, hip	
Osteomyelitis, femur (with epiphyseal involvement)	3
Paralysis spastic hemiplegia, cerebral	
Poliomyelitis anterior residual effects	6
Short leg, congenital	6
Talipes equinovarus	
Tuberculosis hip	6
Tuberculosis knee	4
Volkman ischemic myositis	
Total	53

As of October 29, 1941

the cases, 12 months in 80 per cent, and 9 months in 57.3 per cent.

## COMPLICATIONS

The complications that have been encountered in this series of leg lengthenings have been many. Both their incidence and gravity can be lessened. This can we believe be better accomplished by diligent and understanding postoperative care than by more radical surgical techniques and complex types of apparatus.

The original Abbott technique has been closely followed. The dissection consists, briefly of the usual Z osteotomy of the tibia, oblique osteotomy of the fibula, section of the fascia and interosseous membrane, and lengthening of the tendo calcaneus except when paralyzed. Every effort is made to denude the tibia as little as possible. This is a relatively conservative dissection, but it will yield 2 inches of length handily. There is a strong tendency to bow but it is probably significant that in over 100 cases there have been no deaths, no amputations, and no nonunions.

The lengthening apparatus is modified only in two respects. The four pins fit into individual slots allowing an anteroposterior excursion of about 1 inch. This is often insufficient to control bowing so the extension bars are made of soft steel which can be easily and accurately bent with the bending iron. The fact that this has been done in more than half the cases reflects something of its value to us.

Absolute control over the bone fragments is extremely important. Laziness here leads to the familiar sequence of bowing and separation of the bone fragments, necrosis of the skin aseptic necrosis or low grade osteomyelitis (13 cases) seques-

TABLE II.—GENERAL STATISTICS

Average lengthening obtained, 1.8 inches	
Age groups	No. cases
Under 5 years	13
to 8 years	4
Over 8 years	13
Time to complete bony union	
30 months	For most of
24 months	100
18 months	94
9 months	49
	57

tration (11 cases) delayed union, and genu or pes valgum. However if one is diligent in observation and understands the problem, he can penetrate to the face of these difficulties to obtain adequate length and finally obtain a good end-result.

At the time of surgery one real hazard is fracture of one of the bone tongues, and this occurred four times in our series (of which two were in the femur) and prevented trying for any length. In one case the upper fibular fragment was inadvertently penetrated by a lower pin and had to be replaced when later discovered. In another case the fibular fragments locked one on another and had to be disengaged.

One severe postoperative infection was encountered in which no lengthening was obtained and one child of 7 years had a moderate postoperative infection with massive early callus formation which allowed only about one-half the desired length. There were several cases with mild infections such as a stitch abscess or infected hematoma which delayed the start of lengthening a few days, but thereafter proceeded without untoward event. A number of the cases showed drainage or even sequestration late in the lengthening process, but this was probably incident to aseptic necrosis in most if not all cases. Pin hole infections were annoying and were persistent enough to require curettage in 4 cases.

In several cases the fibula did not lengthen sufficiently. In 2 of the cases it pulled up, interfering with ankle stability and an arthrodesis was thought necessary. More commonly the head of the fibula pulled down. This occurred in varying degrees up to one inch, but in no case did it seem to cause any disability.

There were no permanent nerve palsies. In a similar manner the flexion deformities of the knees, feet and toes surrendered to time and physiotherapy.

It was interesting that there were no cases of nonunion, even though many were long delayed. Table II is rather misleading in that it refers to weight bearing rather than to bony union by x-ray.

After seeing several of these lengthened tibiae, drawn thin by lengthening and fracture underslight provocation, we tended to be rather conservative about allowing unrestricted activity. Partial weight bearing was encouraged after danger of telescoping of the fragments was improbable. Distraction, infection, and increasing age appeared to delay union definitely. We are not sure that mild infection has any deterring effect on osteogenesis other than its interference with the local blood supply at the osteotomy site.

Fractures incident to full weight bearing occurred in 6 cases and in 5 the injury was trivial. The one due to a severe injury had had delayed union following femoral lengthening and immediate open reduction with a bone graft had been performed. In the other cases healing was without complications.

#### PRESENT STATUS OF LEG EQUALIZATION OPERATIONS

At the present time there are 4 proved procedures by which discrepancies in leg length may be overcome. Each has its advantages and while some rules can be laid down, in the final analysis, it will be the judgment of the surgeon that will be the deciding factor.

The first and oldest is amputation and prosthesis. While not popular at present, there are circumstances when it is to be highly recommended. A severe foot deformity coupled with marked shortening of the leg would be ideal for such a procedure, likewise a poliomyelitis victim with a good functional hip presenting severe paralysis of the knee, ankle, and foot in which shortening was severe.

The other methods to equalize leg lengths are shortening of the long leg, epiphyseal arrest, and lengthening of the short leg. At present the former two are in wider use. This is due to their undoubted advantage in many cases plus the fact that surgeons who are familiar with the shortcomings and difficulties of leg lengthening, may be too eager to turn to an operation of the complications of which they are not so uncomfortably aware.

**Epiphyseal arrest.** This is a valuable procedure and will be more useful as we learn more about growth. The surgery is relatively simple and the convalescence short. It has the disadvantage that fusion of the epiphysis may fail or be incomplete, leading to deformity. Likewise we are forced to apply a general rule of expected growth to a specific case, which may give far from the correct answer, particularly since the short leg may have pathology making the growth expectancy even

TABLE III —COMPLICATIONS

	Cases	Cases
Infections		
Severe immediate postoperative infection		1
Osteomyelitis or aseptic necrosis		13
Surgery to correct	11	
Persistent pin hole infection		6
Surgery to correct	4	
Ankle joint fusion		1
Bowing of tibia (over 20 degrees)		8
Surgery to correct	6	
Foot deformities		common
Equinus		
Moderately severe for long period with later spontaneous improvement		
Calcaneus		1
Valgus		2
Peroneal nerve palsy		2
Both eventually recovered		
Ibicular detachment		
Head of fibula pulled down but no functional disability varying degree in at least		12
Distal end fibula pulled up		
Probably will require ankle fusion		2
Delayed union (over 12 months)		17
Fracture of bone tongue at surgery		4
1 Femoral	2	
2 Tibial	2	
Late fractures		6
Miscellaneous		
Loss of appreciable length due to premature removal pins and application cast		2
Inadvertent over lengthening due to spring tension of pins after lengthening stopped		3
Inadvertent drilling upper fibular fragment with lower tibial pin		1
One or more pins broke during lengthening		3
Failure to obtain any or very little length		7
Due to fracture of bone tongue at surgery	4	
Due to severe postoperative infection	1	
Due to inadvertent drilling of fibula	1	
Due to early massive callus formation	1	

more difficult of computation. Generally speaking, epiphysiodesis is indicated if (1) the growth expectancy is compatible with the desired shortening, (2) the growth expectancy may be reasonably computed, both in the long and short leg, (3) it is desirable to combine it with either a leg shortening or leg lengthening operation, either due to severity of the paralysis or to match a destroyed epiphysis in the short leg.

**Leg shortening.** This is the most accurate of all leg equalizing operations and has a wider field of application. The gravity of such major surgery on a good leg is real, particularly if the short leg is of poor power or function. From our experience we prefer to shorten the femur in the subtrochanteric region, using rigid internal fixation. It is a desirable procedure (1) If the shortening exceeds  $1\frac{1}{2}$  inches. (2) After the growth of the leg is at or near completion. (3) If the short leg is a good functional member. (4) If the patient is of normal or above normal height.



*Leg lengthening.* This is a tried operation and has given results to make it worthy of perpetuation although its field of application has been lessened in the past few years. We consider it a sound procedure under the following conditions: (1) If the desired lengthening does not exceed  $2\frac{1}{4}$  inches. (2) If the function of the short leg is too poor to risk surgery on the normal leg. (3) If the patient is in the age group between 12 and 25 years. (4) If bone and soft tissue are of good quality. (5) If the patient's stature is average or short. (6) If the patient refuses to have an operative procedure performed on the long leg.

#### CONCLUSIONS

During the past 12 years the leg lengthening operation has been put to a critical test. Tibial lengthening is a valuable procedure under proper indications. Femoral lengthening has been unsatisfactory. We are now doing more femur shortenings and epiphyseal arrests but do not think that they can supplant leg lengthening.

Leg lengthening will always entail certain hazards and there will probably always be some poor results, but with the experience gained, I feel that the hazards and poor results can be reduced to a creditable minimum.

# A NEW APPROACH TO THE DIAGNOSIS OF HERNIATION OF THE INTERVERTEBRAL DISC

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THE earlier experiences in this hospital<sup>1</sup> in the treatment of herniation of the intervertebral disc were similar to those in many other institutions in that the results were inconsistent and frequently unsatisfactory. Accepted diagnostic methods were employed routinely and much dependence was placed upon neurological and myelographic findings. An analysis of our results indicated clearly that too much reliance upon these criteria had frequently led us into error.

During the past year, a new diagnostic approach has been employed with consistently satisfactory results. This approach is based chiefly upon a study of alterations in both the attitude of the lower spine and mobility of the intervertebral joints, and we have come to recognize a syndrome which we believe to be pathognomonic of the disease in question. We have been able, not only to detect the presence of a herniation, but to predict its level and placement in relation to the midline. This is of great value in directing and reducing the extent of the subsequent operative procedure.

In this preliminary report, we present the use and rationale of these diagnostic methods. A general review of the subject and historical study may be found elsewhere (4).

To present our concept of the pain mechanism on which these diagnostic methods are based,

<sup>1</sup>Hospital for Special Surgery maintained by the New York Society for the Relief of the Ruptured and Crippled New York.

certain anatomical and pathological considerations are necessary. The monograph of Beadle, a student of Schmorl, contains an excellent description of the normal and pathological intervertebral disc, and his work has aided us in correlating physical findings with pathological conditions.

The normal disc is a fibrocartilaginous cushion between the cartilaginous plates of the vertebral bodies. The outer portion of this disc is composed of concentric laminations of dense fibrocartilage, which, on fresh section, are shown as discreet circular rings—annulus lamellosus (Fig 1, b). Centrally, these cartilaginous rings blend imperceptibly with the nucleus pulposus (Fig 1, a).<sup>2</sup>

The nuclear tissue is a loose, semigelatinous mass of fibrocartilage with a fluid content greater than the annulus. This seems to account for its inherent elastic turgor. The unique feature of the system is its expansile resiliency, i.e., its ability to maintain separation of the vertebral bodies and to absorb the countless stresses and strains of normal activity.

Certain other structural features are worthy of note because they undoubtedly affect the course of pathological changes. The joint capsule, which herniations must distend or rupture, is relatively thin over the posterior aspect of the joint in the region of the neural canal. It is re-enforced in the midline, however, by the posterior collateral liga-

<sup>2</sup>Figures 1 and 2 are taken from *The Intervertebral Discs* by Ormond A. Beadle by special permission from His Majesty's Stationery Office.



Fig 1 Normal lumbar intervertebral disc shown in horizontal and sagittal section. Left, a Nucleus pulposus, b, annulus lamellosus

*Leg lengthening.* This is a tried operation and has given results to make it worthy of perpetuation although its field of application has been lessened in the past few years. We consider it a sound procedure under the following conditions: (1) If the desired lengthening does not exceed  $2\frac{3}{4}$  inches. (2) If the function of the short leg is too poor to risk surgery on the normal leg. (3) If the patient is in the age group between 12 and 25 years. (4) If bone and soft tissue are of good quality. (5) If the patient's stature is average or short. (6) If the patient refuses to have an operative procedure performed on the long leg.

#### CONCLUSIONS

During the past 12 years the leg lengthening operation has been put to a critical test. Tibial lengthening is a valuable procedure under proper indications. Femoral lengthening has been unsatisfactory. We are now doing more femur shortenings and epiphyseal arrests but do not think that they can supplant leg lengthening.

Leg lengthening will always entail certain hazards and there will probably always be some poor results but with the experience gained, I feel that the hazards and poor results can be reduced to a creditable minimum.

# A NEW APPROACH TO THE DIAGNOSIS OF HERNIATION OF THE INTERVERTEBRAL DISC

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THE earlier experiences in this hospital<sup>1</sup> in the treatment of herniation of the intervertebral disc were similar to those in many other institutions in that the results were inconsistent and frequently unsatisfactory. Accepted diagnostic methods were employed routinely and much dependence was placed upon neurological and myelographic findings. An analysis of our results indicated clearly that too much reliance upon these criteria had frequently led us into error.

During the past year, a new diagnostic approach has been employed with consistently satisfactory results. This approach is based chiefly upon a study of alterations in both the attitude of the lower spine and mobility of the intervertebral joints, and we have come to recognize a syndrome which we believe to be pathognomonic of the disease in question. We have been able, not only to detect the presence of a herniation, but to predict its level and placement in relation to the midline. This is of great value in directing and reducing the extent of the subsequent operative procedure.

In this preliminary report, we present the use and rationale of these diagnostic methods. A general review of the subject and historical study may be found elsewhere (4).

To present our concept of the pain mechanism on which these diagnostic methods are based,

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certain anatomical and pathological considerations are necessary. The monograph of Beadle, a student of Schmorl, contains an excellent description of the normal and pathological intervertebral disc, and his work has aided us in correlating physical findings with pathological conditions.

The normal disc is a fibrocartilaginous cushion between the cartilaginous plates of the vertebral bodies. The outer portion of this disc is composed of concentric laminations of dense fibrocartilage, which, on fresh section, are shown as discreet circular rings—annulus lamellosus (Fig 1, b). Centrally, these cartilaginous rings blend imperceptibly with the nucleus pulposus (Fig 1, a).<sup>2</sup>

The nuclear tissue is a loose, semigelatinous mass of fibrocartilage with a fluid content greater than the annulus. This seems to account for its inherent elastic turgor. The unique feature of the system is its expansile resiliency, i.e., its ability to maintain separation of the vertebral bodies and to absorb the countless stresses and strains of normal activity.

Certain other structural features are worthy of note because they undoubtedly affect the course of pathological changes. The joint capsule, which herniations must distend or rupture, is relatively thin over the posterior aspect of the joint in the region of the neural canal. It is re-enforced in the midline, however, by the posterior collateral liga-

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Fig 1. Normal lumbar intervertebral disc shown in horizontal and sagittal section. Left a, Nucleus pulposus, b, annulus lamellosus.

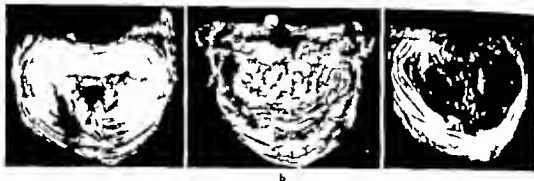


Fig. 2 Common pathological changes. a, Fibrillar degeneration of nucleus and inner annular rings, b, typical

concentric tear of annulus, c, complete degeneration of entire nucleus and inner layers of annulus

ment which probably accounts for the lower percentage of midline herniations. Another important consideration is the relative strength of the bony attachments of the laminated rings of the annulus: posteriorly these rings are more loosely attached than anteriorly and consequently they can be more readily avulsed by a herniation. Furthermore it is important to note that the disc itself has no blood supply and must absorb its nutrition from the cartilage plate. The fluid content of the nucleus diminishes with age and so must its elastic turgor. This loss impairs its ability to absorb trauma without local damage. Finally it must be recalled that the intervertebral discs were primarily designed for flexibility, not the weight-bearing of the upright posture. It is

not surprising then, as Schmorl has pointed out, that the intervertebral disc is one of the first tissues the body to degenerate with age and usage. Thus, from an anatomical, physiological, and phylogenetic standpoint, the intervertebral disc endures a rather precarious existence.

#### PATHOLOGICAL EVENTS

Several types of pathological changes may occur within the disc (a) Fibrillar degeneration of the nucleus and inner lamellar rings (Fig. 2 a), simple concentric tears (Fig. 2 b) as well as complete degeneration of the entire nucleus and large areas of the annulus (Fig. 2 c) have all been described at length and need only be mentioned here.

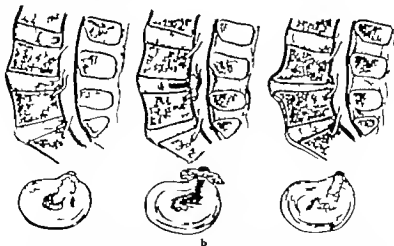


Fig. 3 Three common types of herniations. a, Simple reducible herniation with intact capsule. b, complete extrusion of sequestrum through ruptured joint capsule. c, advanced type with narrowing of disc, bony proliferation, and fibrous involving uninvolved nerve root.



Fig 4 Advanced type of herniation as in Figure 3 c  
Note bony proliferation within the distended posterior joint capsule

Once these pathological changes occur, the intervertebral system loses its elastic resiliency and is consequently unable to maintain normal separation of the vertebral bodies. The volume of the disc has not been altered, only its turgor. As the disc collapses under body weight, the nonresilient, fragmented fibrocartilage is squashed as a semifluid mass, either into the vertebral body (Schmorl's node) or toward the periphery of the joint, there to invade the laminations of the annulus and bulge or rupture the relatively thin posterior capsule. Once this collapse occurs, a balance is restored between the volume and the remaining resiliency of the disc. The herniation has, so to speak, decompressed the disc temporarily. Further degeneration of the disc entails more loss of resiliency, more collapse, and consequently more extrusion of debris into the herniation. These posterior protrusions often impinge upon regional nerve elements, angulating, stretching, or actually pinching the involved nerve (the overlying lamina or ligamentum flavum acting as the other jaw of the pincer), thereby producing segmental pain, paresthesia, or paralysis.

In our experience, three types of herniations are encountered at operation. While quite distinct in individual cases, they probably represent only stages in a natural sequence. First, there is the simple herniating mass of fragmented cartilage

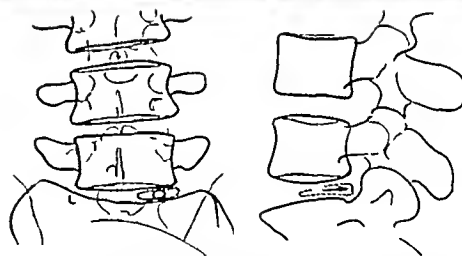


Fig 5 Typical posture of patient with a herniation of the intervertebral disc between 5th lumbar and sacrum on the right side. Note the list to the left and the flattening of the lumbar curve.

and degenerative nuclear material distending the intact posterior capsule (Fig 3, a). At operation, this appears as a tense, rounded bulge of the posterior capsule having the consistency of a tennis ball. When the thin capsule is incised, the fragmented cartilage either extrudes spontaneously or can be delivered by traction. In the second type, the joint capsule has been ruptured and the cartilaginous sequestra have migrated into the extra-

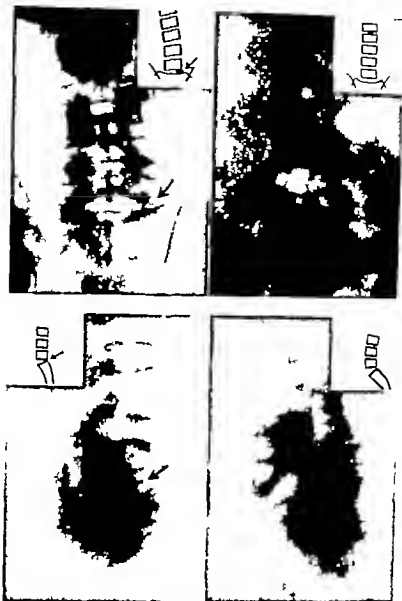


Fig 6 a, above, Preoperative, and b, postoperative, views demonstrating the prompt restoration of posture following operative removal of disc protrusion and cartilaginous sequestra.

dural space (Fig 3, b). Finally, the third type is characterized by fibrous fixation of the protrusion and involved nerve elements and frequent bony proliferation within the joint capsule (Figs 3 c and 4). This may occur in either of the two previously mentioned groups, and probably represents a late stage in the pathological sequence.

The clinical behavior, especially the response to rest in bed, has often been so distinct in each of these three groups of cases that we have frequently been able to predict the type of herniation subsequently found at operation.

The first type with the simple bulging of the intact joint capsule has almost always responded

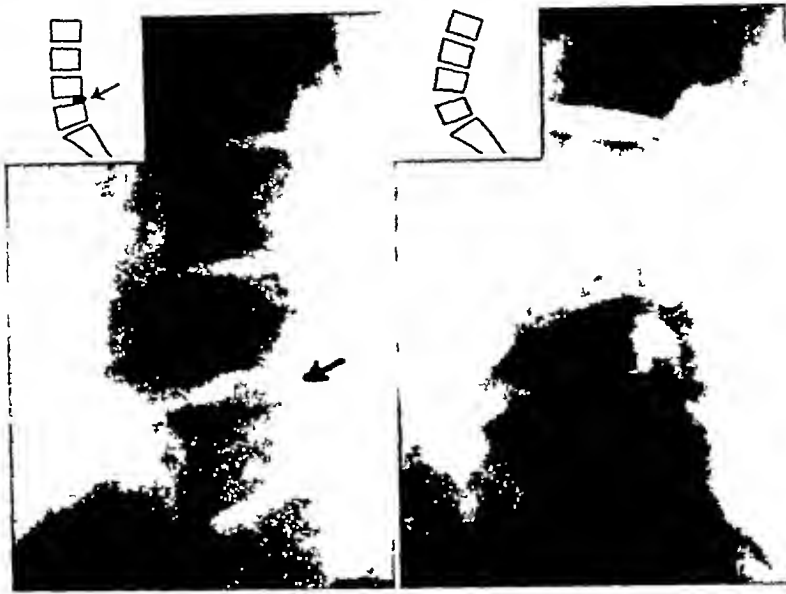


Fig 7 a left, Preoperative, and b, postoperative views, showing restoration of lordosis in a patient who had a herniation removed from the disc between 4th and 5th lumbar vertebrae

well to complete bed rest. Usually within a few days there has been a striking relief of pain. So much so, that in our opinion this readily reducible "fluid type" of herniation should be given a trial of conservative treatment to allow the herniation to become fixed in a position which does not involve the nerve roots. The latter two types have, for the most part, shown little or no improvement with bed rest.

#### DIAGNOSIS

A patient with a herniation of an intervertebral disc really suffers from two lesions: a traumatic neuritis of the involved root or roots, and a diseased intervertebral joint. Since the neurological manifestations are much more obvious than the disturbance to the mechanism of the intervertebral joint, attention has been focused on the traumatic neuritis associated with this lesion, and the disease in the joint itself seems to have been overlooked. As might be expected, a uniform type of lesion of the intervertebral disc produces a uniform alteration in the mobility of the involved joint. This disturbance of joint mobility has been so consistent in our disc cases that we have come to recognize a definite syndrome on the basis of which the diagnosis and preoperative localization of the lesion has been possible.

The attitude of a deranged joint is usually determined by two factors, the mechanical limitation within the joint itself and the position of

maximum comfort. How do these criteria apply to the typical postural deformity of a disc protrusion, i.e., the attitude of flexion of the spine and list away from the side of pain?

The intensity of peripheral pain or paresthesia is proportional to the force of the herniation against the involved root or roots. This forceful extrusion of the herniation depends entirely upon the amount of compression of the diseased or sequestering area of the disc. Thus a patient with a disc protrusion faces the problem of transmitting the body weight along the spinal column without compressing the diseased area of the disc, thus avoiding further extrusion of the cartilaginous debris along the course of the herniation. To do this, one must tilt the spine away from the involved area of the disc. This posture entails a list of the spine away from the side of the lesion, and, since the mass is extruding posteriorly, an attitude of forward flexion is assumed (Fig 5).

If the lesion is laterally placed in the intervertebral space, the prominent spinal deformity will be a lateral list, while in a more centrally placed protrusion, the outstanding postural deformity will be a flat back or a kyphosis due to flexion of the spine. Usually the two deformities appear in combination. The predominance of one or the other indicates the placement of the lesion within whatever disc may be involved.



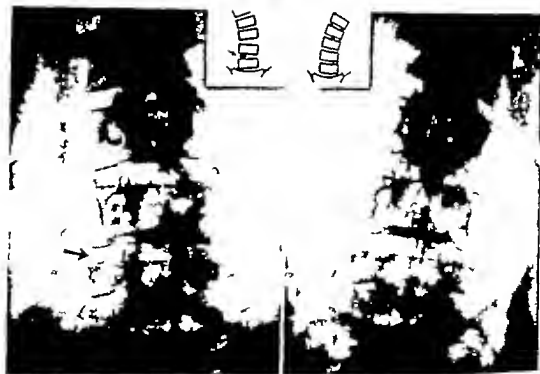
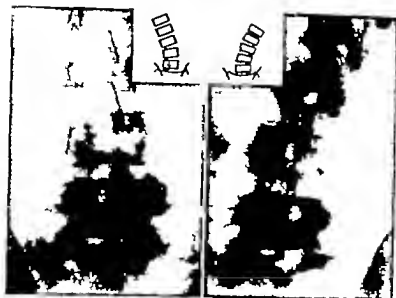


Fig. 8. Above, Preoperative views of lateral bending to right and left showing disturbed mobility of the involved joint, particularly on the side of the lesion. Note that when the patient bends to the side of the lesion (right) the

lumbosacral disc fails to compress as do the discs above. Note on bending away from the lesion (left) the disc has more normal mobility. b. Another patient demonstrating a block between 4th and 5th lumbar vertebrae on right side.

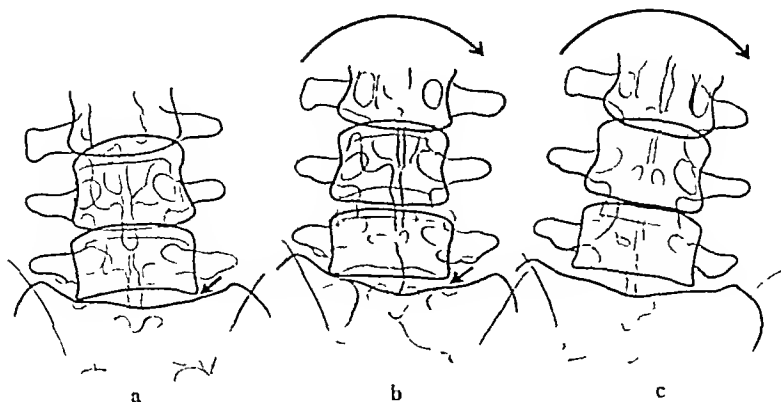


Fig 9 A series of tracings made from films of a patient who had a herniation removed from the right side of the lumbosacral joint. Note how the herniating sequestrum (arrow) tilts the normal standing posture, a, and obstructs lateral flexion of this joint, b. The postoperative bending view, c, indicates restoration of mobility within this joint.

It has been noted that after a time, the spinal deformity apparently becomes fixed. Even during the occasional remission of symptoms and under anesthesia sufficient to permit complete muscle relaxation, the deformity is unchanged. We believe this fixation of postural deformity to be due to the presence of noncompressible cartilaginous sequestra within the diseased area of the joint. As stated one characteristic of a degenerating disc cartilage is its loss of resiliency. Like the fragments of a bucket handle tear of a meniscus of the knee joint, these sequestra naturally migrate to the roomier portions of the intervertebral space which have been opened up by the protective tilting of the spine and there act as a mechanical obstruction to the mobility of the joint. Comparison of films taken before and shortly after operation reveals a striking restoration of posture once the sequestrum has been removed (Figs 6 and 7).

Realizing the diagnostic implications of the presence of a mechanical derangement within the involved intervertebral joint, we have attempted to visualize this feature more clearly by taking special bending films of the patient in lateral flexion to both sides and in forward flexion and extension. In the majority of our cases, these films have demonstrated a lack of spinal mobility localized to the involved joint. On the involved side, the joint may fail to narrow as much as the joints above and below or may even remain wedged open. Bending to the painful side usually demonstrates little, if any, resiliency within the affected joint (Fig 8). (These films are best obtained with posteroanterior views of the patient standing, bending as far to each

side as possible. The tube should be centered over the upper lumbar area and tilted caudally 15 to 20 degrees. This will allow good visualization of all the lumbar and some of the dorsal interspaces.)

Lateral views of the spine with the patient in extreme flexion and extension may also demonstrate a mechanical obstruction in the posterior aspect of the joint which will be apparent in the view in extension. The involved disc will fail to allow extension as do the joints above and below. It should be emphasized that these "bending

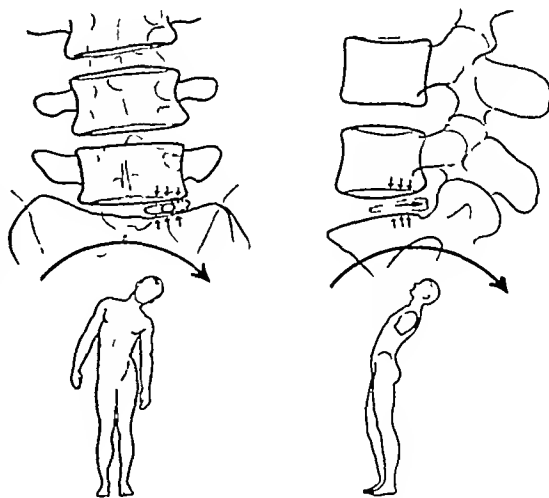


Fig 10 Pain mechanism. Diseased cartilage and herniation are indicated by dotted lines. Arrows indicate the mechanical forces that are compressing the diseased area and thereby extrude the herniation against the root.

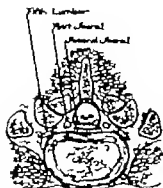


Fig. 3b

Fig. 3 Drawings made from dissections of lumbar region show placement of nerve elements in relation to bony structure. Note how single root may be involved at one of the levels and how at any one level one of two roots or the cauda equina may be involved.

2. *Articular lesion.* These cases are characterized by recurrent sudden attacks of low back and leg pain, often following a back twist or minor trauma. These may be due to a subluxation of one of the posterior articulations or sacroiliac joints, or a congenitally abnormal articulation. There is often an extreme postural deformity with a list and kyphosis identical with that of a disc lesion and they may also have pain on hyperextension and lateral flexion toward the painful side as these motions force the subluxated joint. The main distinguishing feature is the pain on passive flexion and more particularly on rotation.

3. *The mechanically unstable back.* Instability of the bony structure of the spine due to congenital defect spondylolisthesis etc., aggravated by faulty posture, obesity, and acute or chronic trauma often leads to recurrent low back and leg pain. There is usually limitation of motion in all directions in the affected area of the spine. With age the symptoms become arthritic in character. Attacks are usually relieved by rest, external support, and restoration of muscle tone.

4. *Arthritis.* Specific and nonspecific inflammation of one or more joints of the spine and pelvis. Pott's disease and early Marie Strömpeff arthritis may on superficial examination be confused with a herniation of the intervertebral disc. General physical examination and laboratory data will help to differentiate these cases.

5. *Sciatic neuritis.* A toxic neuritis, usually associated with an inflammatory process elsewhere in the body has frequently been observed. These cases present extreme unilateral pain and limitation of straight leg raising. Ankle jerks may be absent, and paresthesia present. Such a lesion is

differentiated on the basis of normal mobility of the lumbar spine and opposite extremity.

6. *P. sternal low back pain.* The syndromes described by Kindell and Hodson are common clinical entities. Advanced cases may present a history and symptomatology similar to that of a disc lesion. They may be differentiated by an analysis of the postural deformity and the detection of fixed muscle contractures.

#### TREATMENT

*Conservative.* We agree with others (1) that not all cases of disc protrusion warrant laminectomy. The readily reducible fluid type of herniation which has not ruptured through the joint capsule and which becomes painless after rest in bed should be treated by conservative means if possible. Undoubtedly it is this type of lesion which has responded to spine fusion in the past.

*Operative.* Once the diagnosis of a disc protrusion has been made the indications for operation are any of the following: (1) pain—unrelieved by usual conservative measures; (2) severe fixed spinal deformity; (3) profound neurological disturbance.

The operation consists of removal of the herniated mass and any sequestered material within the disc. The extradural approach is used unless an intradural lesion is suspected and, in the majority of cases, this can be accomplished with little

or no removal of bone. Occasionally, it may be necessary to perform a hemilaminectomy, or to remove one of the posterior articulations to expose a laterally placed lesion.

#### SUMMARY

It is obvious from the literature on the subject that herniation of an intervertebral disc in the lumbar region is a common cause of low back and sciatic pain. There is, however, a dissension of opinion in regard to diagnosis and treatment which is due largely to the inadequacy of presently accepted diagnostic methods and an incomplete understanding of the lesion itself and its pathological sequences.

We have greatly increased our diagnostic accuracy by a return to the fundamentals of orthopedic examination, namely, the study of posture and joint mobility, and by the application of the

x-ray to the study of mobility and posture (known as bending films). A clinical syndrome is described which will differentiate the condition from other disorders affecting the lumbosacral spine.

Three types of lesions have been distinguished, a "fluid" or reducible type, a sequestered type, and a third or fixed type which probably represents an end stage in the process. A trial of conservative therapy is recommended, and indications for operation are stated.

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### WHIPPLE'S DISEASE

**I**N 1907 Whipple described a disease which was "characterized anatomically by deposits of fat and fatty acids in the intestinal and mesenteric lymphatic tissues, and which he termed *intestinal lipodystrophy*. This disorder caused loss of weight to the point of emaciation, loss of strength, microcytic anemia, recurrent arthritis, doughy swelling of the abdomen associated with tenderness and gaseous distention, abdominal pain and fatty diarrhea with an average of three or four stools a day which were light or clay colored and consisted of over 50 per cent fat and fatty acids by weight. There was no interference with fat splitting for the fat in the stool was almost completely composed of split fat and soaps in crystalline form.

This disease is rare but should be recognized when encountered for otherwise an erroneous prognosis may be given. The symptoms of abdominal pain often in the right upper quadrant associated with vomiting, ga. and in

tolerance to fats may suggest gall stones. The abdominal distention, cramp-like pain, vomiting and x ray changes in the intestinal pattern may lead to a diagnosis of partial intestinal obstruction. Tuberculosis may be thought of because of the emaciation, loss of appetite,

doughy consistency of the abdomen, and diarrhea. Carcinomatosis may be considered from the finding of palpable nodules in the abdomen associated with anemia and emaciation. The operative findings may also be confusing. When the abdomen is opened the viscera are seen to be matted together in one solid mass. After the adhesions are freed the loops of intestine appear bound together by a colloid substance but when they are separated a viscous fluid is released which is not gelatinous. The intestinal loops are red, granular covered with a shaggy exudate and in some locations spotted with small white nodules resembling tubercles. The mesenteric lymph nodes may be greatly enlarged and prominent. Scattered throughout the peritoneal cavity in the liver and on the intestines, omentum and parietal peritoneum are hard, pale pink nodules that appear typical of carcinomatous implants. However, when these are cut they are found to be thick walled cysts with a central cavity containing a yellow oily substance. This differentiates the condition from pseudomyxoma peritonei or colloid carcinomatous which, at first glance, are suggested.

The pathological changes as originally described by Whipple may be summarized as follows. The epithelium of the intestinal mucosa is normal, the villi of the small intestine are enlarged by deposits of neutral fats and fatty acids while the submucosa shows lamina propria with polyblastic cells about fatty de-

<sup>1</sup>Whipple, C. H. Bull. Johns Hopkins Hosp., 1907, 8, 23

posits. Wherever it is found, the fat may be present in a variety of forms from minute grains to huge irregular droplets containing rosettes of fatty acid crystals. The majority of the larger deposits are outlined by polyblasts—large mononuclear ameboid cells with pink granular protoplasm and by foam cells with a pale vesicular nucleus. These are most conspicuous in the mesenteric glands in which progressive changes occur, the final stage being “a very large gland packed with fat deposits of all sizes and shapes whose stroma is made up of dense fibrous tissue full of echymoses and great numbers of giant and mononuclear cells.”

Recently, an opportunity was presented to study this disease in a patient having the diagnosis made from material removed at abdominal exploration. The concept of Whipple that the disorder was due to malabsorption of fat without interference with fat splitting was confirmed. Study of the formed elements of the blood, glucose tolerance, serum protein, and minerals showed them to be normal. The level of phospholipid, cholesterol, and total lipids in the blood was not unusual. There was 59.5 per cent of lipid in the dry stool of which the greater part was split fat. Vitamin A absorption was greatly reduced. The oily substance found in the center of the intra-abdominal nodules contained 74 per cent fatty acid. Apparently, these nodules result from a fibroplastic reaction around fat that is liberated within the peritoneal cavity. The malabsorption and abnormal liberation of fat suggested a fault in the bile and so led to a trial of bile salt medication.

It was found that with adequate dosage of bile salts the symptoms disappear, appetite and strength return, weight is gained, vitamin A absorption improves and the fat content of the stool approaches normal. The symptoms

return if the bile salt administration is stopped and are relieved with resumption of treatment. This suggests a fault in bile salt metabolism either by deficient production or from abnormal loss of the bile salts. Lack of suitable analytical methods prevents proof of this theory of the cause of the disease but for the present, at least, this concept gives a satisfactory method of its treatment.

HERMAN E. PEARSE

## MENINGITIS IN HEAD INJURIES

**M**ENINGITIS follows trauma to the head in only a relatively small proportion of cases. Munro gives the rate of occurrence as 1.3 per cent. In 2,740 cases of head injury treated on the neurosurgical service at the Cook County Hospital during 1939 and 1940 meningitis occurred in sixteen cases—0.58 per cent. In spite of its relative infrequency, meningitis accounts for from 3 to 8 per cent of the deaths from head injury. In the group of cases referred to above there were 361 deaths, 10 or 2.8 per cent of which were due to meningitis. Vance, reporting on 507 necropsies in patients dying from head injury, found 41, 8.1 per cent, to be due to meningitis. In only 2 of these cases did meningitis follow compound fracture of the vault of the skull, the rest followed basal skull fracture. This is probably a correct ratio as far as civil practice is concerned. Of course, in war wounds the percentage of cases due to compound fracture will be much higher. Cairns recently reported 24 cases of gunshot wounds of the head with 2 cases of purulent meningitis and 2 other cases of epidural abscess with associated meningitis.

Munro states that the staphylococcus is the most frequent infecting organism, streptococcus next, then pneumococcus, and finally the influenza bacillus. Other writers emphasize the importance of the streptococcus

and pneumococcus. Five of 11 recent cases in the writer's experience were due to pneumococcus. Clark reported 4 cases of meningococcus meningitis from Bellevue and 16 more from the literature that had followed basal skull fracture. It is probable that these individuals harbored the meningococcus in their nasopharynx and the basal skull fracture provided an avenue for entry of the organisms into the intracranial cavity. Gross and Ehrlich emphasized the danger of fracture of the petrous portion of the temporal bone in the presence of acute or chronic otitis media or mastoiditis. Cases of otorrhea and rhinorrhea have long been recognized as likely to develop meningitis and rhinorrhea justly has the worst reputation in this respect.

Meningitis following head injury may be divided into two groups: fulminating and delayed. In the latter symptoms do not appear for several days or longer after the injury and the patient seems to be well out of danger at least as far as infection is concerned. The symptoms of meningitis following head injury are similar to those of meningitis due to other causes. Headaches, vomiting, fever, photophobia, delirium, stupor, incontinence, stiff neck, and a positive Kernig sign are the most common symptoms. Since many or all of these symptoms can be due to brain injury especially if associated with subarachnoid bleeding it is therefore necessary to do a spinal puncture if there is any suspicion of meningitis. The spinal fluid is typically under high pressure and cloudy with a marked pleocytosis with polymorphonuclear leukocytes. The total protein is increased and the sugar and chloride content are lowered. Cultures reveal the offending organism. Often the spinal fluid is blood tinged or frankly bloody due to subarachnoid hemorrhage. Differential cell count may then be of some value but diagnosis depends on the results of culture

In the past mortality has ranged from 40 to 100 per cent being considerably nearer the latter figure in proved cases. Because of this high mortality a number of procedures have been tried by various surgeons. Among these are frequent or continuous spinal drainage, laminectomy or suboccipital craniectomy with continuous drainage of fluid and intracranial injections of antisera or antiseptic solutions. The advent of sulfonamide therapy has materially altered the possibility for cure in all types of purulent meningitis. Grant has stated that the mortality for posttraumatic meningitis should be lowered to 25 per cent. Some writers have advised the prophylactic administration of sulfanilamide in cases of compound fracture or of drainage of cerebrospinal fluid to the exterior. Gurdjian advises against it. He reported 3 cases of posttraumatic meningitis that recovered on sulfanilamide therapy. Two of these were due to hemolytic streptococci; cultures of the spinal fluid were negative in the other. In all 3 the condition was recognized early.

General prophylactic measures are very important in cases of scalp laceration, compound fracture, bleeding from ears or nose, pneumocephalus, and otorrhea or rhinorrhea. Thorough and meticulous débridement of all wounds involving scalp and bone should be carried out with excision of contaminated and devitalized tissue. If the dura is penetrated the cerebral wound should be débrided by appropriate neurosurgical methods—using suction and irrigation. If foreign bodies are present they should be removed unless that would entail damage to uninjured cerebral structures. These are major neurosurgical procedures and must be postponed until the condition of the patient permits and the proper operative conditions can be attained. However the sooner it is done after the injury the better but good results can be obtained

when operative procedures have been delayed as long as 72 to 96 hours. In such cases the preoperative and postoperative prophylactic administration of sulfonamides is of value but must never be substituted for proper surgical treatment. Primary closure of these wounds is usually advisable.

Patients with bleeding or drainage of cerebrospinal fluid from ear or nose should be kept flat in bed. There must be no interference with the drainage and irrigations are strictly contradicted. Drainage of cerebrospinal fluid from the ear almost always stops spontaneously within 48 hours, drainage from the nose usually does so. If it does not do so within 72 hours plastic closure of the dural defect should be undertaken through a transfrontal craniotomy, the condition of the patient permitting. This should only be undertaken by a competent surgeon under proper operating conditions.

Cases of fracture involving the frontal sinus with or without external compounding of the wound should be operated on as other cases of compound fracture. They are otherwise likely to develop pneumocephalus and meningitis is very likely to follow.

If symptoms of meningitis appear in a patient that has had a head injury, spinal puncture should be done at once. If there is a pleocytosis, sulfonamide therapy should be begun without delay. Sulfanilamide may be

given until the organism has been identified. If the infection is due to a pneumococcus, the organism should be typed and appropriate antisera if available should be given. Sulfapyridine should be given in such cases. Daily blood levels of the sulfonamide used should be determined, and a blood count should be done daily. The new drug sulfadiazine may prove of value in meningitis. Lumbar puncture should be performed every one to three days until the cell count is normal and cultures are sterile. The sugar and chloride content will approach normal as the infection clears and therapy should be continued for several days after the patient has clinically recovered and the cerebrospinal fluid findings are normal. Only by early and intensive treatment can we hope to approach the goal of a 25 per cent mortality which was set by Grant.

Supportive measures of a high fluid and caloric intake, adequate sedation, and blood or plasma transfusions as indicated, must not be neglected. If a patient is comatose or incontinent, the special nursing care that such cases require must be furnished. The recoveries now reported in the literature indicate that posttraumatic meningitis no longer presents a hopeless prognosis but rather a clear cut challenge to the surgeon to make an early diagnosis and institute appropriate treatment.

HAROLD C. VORIS



# THE SURGEON'S LIBRARY

## REVIEWS OF NEW BOOKS

**I**n Doctor Gorich *Perineoptric Anatomy* the proctologist is presented with textbook of distinctly modern type, its publication virtually coinciding with the recognition of anorectal surgery full fledged specialty.

The work is one of a fundamental nature, being concerned with the structure of the canal and of its supporting elements, rather than with surgical method by which the normal relations of the parts may be restored. In his preface to the reader Dr Gorich points out that fundamental training for the specialist is rarely offered by the standard textbooks of gross anatomy less frequently arranged for in the curriculum of the regular medical school. These circumstances are an invitation to competent practitioners, either alone or in collaboration with anatomists, to prepare instructional volumes for the use of aspirants in gynecology proctology thoracic surgery etc.

The text presents the anatomy of the anal canal, the anocanal and subanocanal structures intrinsic anorectal musculature the pelvic and urogenital layers and associated spaces and the nerves and vessels of supply. Of the original figures, some forty are simple diagrams equal in number are photographs of dissection and sections (the latter gross and microscopic). The author uses an even larger number of borrowed figures from textbooks and journal articles, divided about equally between diagrams and detailed drawings. Some of the drawings are very instructive, but would be more serviceable were they accompanied by drawings from actual dissections, of the same set of structures. The use of photographs of dissections is not altogether fortunate, since such pictorial records are, in the present state of this mechanicochemical science, somewhat baffling—the registered lights, shadows, and depths being unfamiliar to the reader. There is no doubt that for the genius of the skilled anatomical artist.

The account of the diaphragmatic supports seems rather inconclusive. The description of the rectal and sigmoid curves could be improved by a discussion of the more common variations in branching. Some of the variations in arterial pattern are so profound that knowledge of their existence could be vital to the gynecologist.

The long list of pelvic spaces serves to make the anatomy of the subcutaneous connective tissue rather forbidding, even to the well informed reader. New names are offered, but established ones are simpler, more descriptive and universally understood. In recent years, through the efforts of the Basic Commission, thousands of unnecessary synonyms have been dropped from anatomic nomenclature. It would seem unwise to drag back, into the anatomical workshop, superfluous verbal tools which are no better than those recently discarded by highly intelligent commission.

Barry Acker

PERINEOPTRIC ANATOMY FROM THE PROCTOLOGIST'S VIEWPOINT  
By R. V. Gorich, A.B. M.D. New York, The Thompson Co., 1941

## BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

**COLLECTED PAPERS OF THE 31<sup>ST</sup> CLINICAL TO THE 31<sup>ST</sup> TO FORTH FROM** Edited by Richard M. Hewitt, B.A. M.A. M.D. A.B. Newburg, M.D. John R. Miller, B.A. Sc.D. James R. Eckman, A.B. and M. Katharine Smith, B.A. Vol. 31 Philadelphia and London W. B. Saunders Co., 94.

**THE OPERATING FORMULARY** Compiled by G. Griffin Lewis, M.D. F.A.C.S. Springfield, Ill., and Baltimore, Md. Charles C. Thomas, 94.

**PHYSICIAN'S REFERENCE BOOK OF EMERGENCY MEDICAL SERVICE PRESENTING THE PRACTICAL EXPERIENCE AND LITERATURE ACQUIRED BY HANDLING CIVILIAN WAR CASUALTIES.** New York E. R. Spaulding & Sons, 94.

**THE PRINCIPLES AND PRACTICE OF CARDIOLOGY** By Crighton Bramwell, M.A. (Camb.) M.D. (Mun.) F.R.C.P. (Lond.) and John T. Klay, A.B. M.D. F.A.C.P. London Haysbury Milford, 94.

**A MONOGRAPH ON ADOLESCENT SPONDYLITIS OR ACUTE LUMBAR SPONDYLITIS** THE EARLY DIAGNOSIS AND ITS

TREATMENT BY WILHELM FELD, A.R. TRANSLATION BY G. Gilbert Scott, M.R.C.S., L.R.C.P. F.R.C.P. D.M.Sc. (Camb.) London Haysbury Milford, 1941.

**THE SELF-PAINING COMPOSITION IN THE TREATMENT OF ISCHEMIA.** By MURIEL A. Schaeffer M.D. Ph.D. (Harv.) Henry A. Christian, A.M., M.D. LL.D. Sc.D. (Harv.) F.A.C.P. Hon. F.R.C.P. (Can.) New York, London, Toronto Oxford University Press, 94.

**THE MANAGEMENT OF FRACTURES, DISLOCATIONS, SPRAINS** By John Albert Key B.S. M.D., and H. F. A. Cornhill, M.D. F.A.C.S. 3d ed. St. Louis The C. V. Mosby Co., 94.

**MANUAL OF STANDARD PRACTICE OF PLASTIC AND MAXILLOFACIAL SURGERY** Prepared and edited by Sub-committee on Plastic and Maxillofacial Surgery. Committee on Surgery. Division of Medical Sciences of the National Research Council, and Medical Department U.S. Army Philadelphia and London W. B. Saunders Co., 94.

**ESSENTIALS OF PATHOLOGY** By Lawrence H. Smith, M.D. and Edwin S. Grant, M.D. 3d ed. New York and London C. Appleton-Century Co. Inc., 1941.

**MORPHOLOGY ANATOMY; A COMPLETE SYSTEM OF TISSUE** Edited by J. Parsons Schaeffer A.M. M.D. Ph.D. Sc.D. 3d ed. Philadelphia The Blakiston Co., 94.

# SURGERY

## GYNECOLOGY AND OBSTETRICS

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### DRAINAGE OF THE COMMON HEPATIC DUCT

With Special Reference to Bile Peritonitis, Wound Infection  
and Other Complications

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**T**HIS study was undertaken in an attempt to evaluate certain points in the technique of operation on the common bile duct reported by us in 1935 (2). At that time, we described a method of draining the common hepatic duct with a rubber catheter, brought out through a stab wound in the right flank, along with a short cigarette wick, which was placed in the subhepatic fossa (Morison's pouch). We advocated tight closure of the original vertical (right paramedian) incision and stated our belief that this technique would give a lower incidence of infected wounds and incisional hernias. Recently, we published (3) follow-up studies on 775 patients, who had had common duct exploration, with special reference to the graded dilatation of the sphincter of Oddi and reported 4 fatal cases of bile peritonitis. The present analysis includes a review of 18 cases of bile peritonitis in that series of operations.

Of the 775 patients, who had exploration of the common bile duct, there were adequate data for the present study on 744, 479 of these had external drainage of the region established through the main incision, as has

been the custom in this hospital for many years. Since there have been an adequate number, 233 cases treated by separate, carefully planned, stab wounds for drainage with tight closure of the main incision, to draw comparisons, we wish to present these data.

Transverse incision was used in only 32 individuals with 3 instances of major wound infection and 3 subsequent hernias in scar. This number is too small to be of much significance and, for this reason, has been excluded from further analysis; the figures, however, suggest an incidence of infection and hernia comparable to that in patients drained through a vertical incision.

Table I shows the types of incision with the number and percentage of major wound infections, wound separations, subdiaphragmatic abscesses, and subsequent hernias in scar.

The table shows that there was at least four times as much major wound infection and eight times as many incisional hernias when drainage was established through the main wound, as when separate wounds were made for drainage. There were 8 cases of complete wound dehiscence following drainage through the main wound, while no such complication

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TABLE I—TYPES OF INCISIONS AND SEQUELAE

No. cases	Drainage through vertical incision		Stab wound drainage		Drainage through transverse incision	
	No.	Per cent	No.	Per cent	No.	Per cent
Major wound infection	70	4.6	8	3.4	3	9.3
Dehiscence	8		7			
Subdiaphragmatic abscess	4		8		85	
Hernia in scar	34	2			85	3.9
Deaths	4	3	9	3.8		

occurred in any case when drainage was established through a stab incision. There were 4 instances of subdiaphragmatic abscess in individuals drained through the wound and 3 when stab wound drainage was established giving essentially the same percentage. The danger of subdiaphragmatic abscess, as a complication of stab wound drainage, has been stressed as a serious objection to the method. We feel that this important question of drainage has been adequately answered by our experience.

It was found that opening the duodenum increased the incidence of wound infection and this was true whether the duodenum was opened for transduodenal exploration of the common duct or for closure of a fistula between the duodenum and gall bladder.

TABLE II

	No. of cases transduodenal exploration	No. of cases closure of duodenal fistula	Total cases	Wound infection
Stab wound drainage	8	6	14	4
Wound drainage	5	4	9	0
Total	13	10	23	

There were 13 patients in whom the common duct pathological process necessitated transduodenal exploration and 10 who had established a fistula between the gall bladder and the duodenum. In this group of 23 cases, 14 had drainage established through a stab wound. Four of these developed major infection in the primary wound, accounting for one half of all the cases of wound infection in a total of 23 counter drainage cases. It is fair to state that there have occurred a few cases of minor infection in the stab wound itself. Rarely has this caused serious delay in the convalescence and in no instance did it require further surgery.

TABLE III—INCIDENCE OF INFECTION EXCLUDING CASES OF OPENED DUODENUM

	No. cases infection	No. cases infection	No. cases infection
Drainage through vertical incision	460	64	13.9
Stab wound drainage	279	4	1.4

During the same period of time the incidence of sepsis, hernia, and evacuation in wounds drained after operation for acute cholecystitis was practically identical with that of drainage through the wound after common duct exploration (6).

TABLE IV—INCIDENCE OF SEPSIS, HERNIA AND DEHISCENCE AFTER DRAINAGE

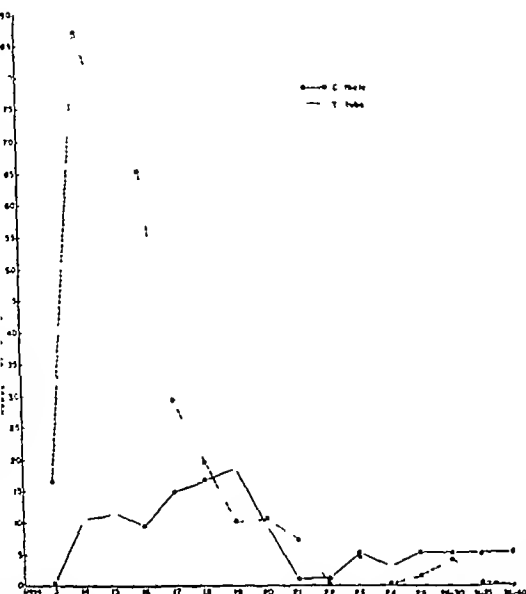
	Per cent infection	Per cent hernia	Per cent dehiscence
Drainage through vertical incision	14.6	7	1
Common duct exploration			
Operation for acute cholecystitis	6.6	3.3	1

The average postoperative hospital period was 16.1 days following stab wound drainage and 18.7 days following drainage through the wound. Of those patients drained by a stab wound, 75.8 per cent were discharged from the hospital by the 16th day and only 44.7 per cent of those drained through the wound could be discharged that soon after operation. The cause of delayed hospitalization over 20 days for survivors is shown in Table V. Of those with stab wound drainage 9.4 per cent were delayed in contrast to 19.4 per cent whose drainage was established through the operative incision.

TABLE V—PROLONGED HOSPITALIZATION (OVER 20 DAYS)

	23 stab wound	10 through wound
Wound infection	8	39
Prolonged bile drainage	5	46
Pulmonary complications	4	7
Bile peritonitis		5
Study for other diseases		3
Dehiscence		4
Subdiaphragmatic abscess		
Miscellaneous	4	1
	13	93
Per cent of total	9.4	19.4

The chief reason for prolonged bile drainage was pointed out in previous publications and has no relation to the position of the drainage tube. Greatly prolonged drainage of bile means



Graph 1 Comparative hospital days for patients in whom catheter and T-tube drainage of the common duct is used

that adequate outlet for bile into the duodenum had not been established (2, 3)

All cases of bile peritonitis were reviewed and two definite causes were found—closure of the common duct without drainage and failure of the drainage tube to drain bile following operation. All cases with no tube left in the common duct and all cases with no drainage of the bile from the tube used for drainage were analyzed. The similarity of the two groups in regard to bile peritonitis is apparent. The mechanism seems the same in both cases and is essentially bile leakage from the common duct either through the repaired opening or around the nonfunctioning tube, if there is free flow to the outside, the convalescence is smooth, if not, some degree of bile peritonitis occurs, which carried a mortality of 22 per cent.

TABLE VI —MORTALITY

	No. cases	Bile peritonitis	Deaths	Per cent mortality with bile peritonitis
Common duct closed without drainage	28	9	1	
No bile through drainage tube	29	9	3	
Total	57	18	4	22.2

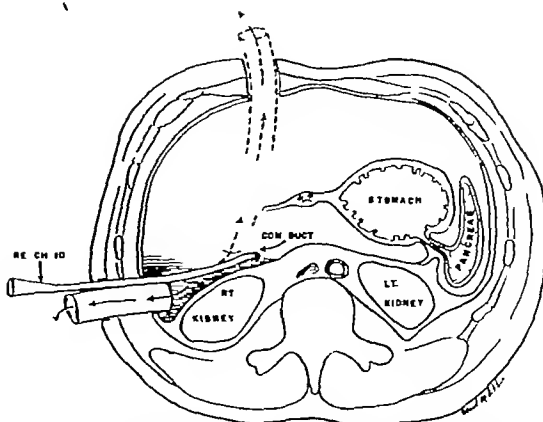


Fig 1 Schematic drawing, modified after Morison, illustrating cross section of the human body at level of the foramen of Winslow. The shaded area shows the pooling of bile and serous drainage from the gall bladder bed and common bile duct. Note the short cigarette wick draining the region at a low level. The only foreign body left in the area of operation is a small rubber tube draining the common duct in which the opening has been tightly sutured around the tube. This minimizes extravasation of bile elsewhere in the abdominal cavity and adhesions between the duodenum and the gall bladder region. The dotted tube leading through the original incision in the abdominal wall transverse a much longer course and must increase the extent of adhesions, if used.

There was only 1 case of the 28 closed without a tube in the common duct, which drained no bile into the dressing. This patient had a very large duct and convalescence was quite smooth, which shows that watertight closure can be accomplished, but this is difficult and so generally unreliable that it should, in our opinion, rarely be attempted.

An attempt was made to determine why there was no bile drainage through the tubes used in 29 cases. All of these patients drained bile into the dressing and, as stated previously, those who drained freely to the outside had a

TABLE VII —NONFUNCTIONING DRAINAGE TUBE

Type of drainage tube	No.
Catheter	20
T tube	6
Not stated	3
A catheter was used 3 times as often as a T tube in the whole series	
Type of incision for drainage	No.
Through wound	19
Through stab wound	8
Not stated	2
Operative wound drainage was used twice as often as stab wound drainage in the whole series	

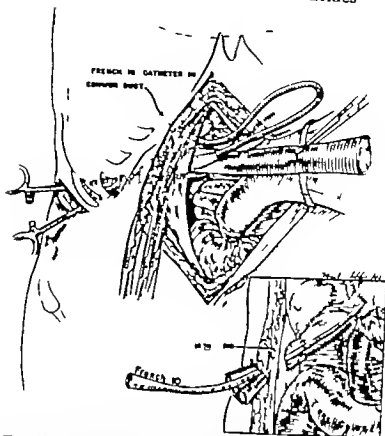


Fig. 2. Schematic drawing illustrating the introduction of common duct drainage tube and cigarette wick through stab wound in the right flank, 2 1/2 inches below the ribs. This must be done under vision, since it is possible to damage the hepatic flexure of the colon or pull omentum through the wound if care is not taken in the maneuver. The inset shows the proper location of the tubes in the abdominal wall cut away.

relatively smooth convalescence while the others were stormy. The type of drainage tube and the type of wound closure (Table VI) had no apparent influence on the malfunction of the tube.

Of the 4 fatal cases of bile peritonitis, 2 had stab wound drainage and 2 were drained through the wound. This amounts to twice as many deaths from bile peritonitis when stab wound drainage was used. We stress this point in spite of the small number of cases, because we believe that others may avoid some of our earlier difficulties. There are a variety of technical errors, which explain failure of the tube to function. These are kinking of the tube, ligature or stitch around the tube, pull-

ing of end of the tube from the duct, and adhering together of the sides of the tube. The importance of using tubes of fresh rubber cannot be overemphasized. This is brought out by an unfortunate death in the series. In removing a tube on the 10th day of uncomplicated convalescence the tip distal to the fixation stitch remained in the common duct. This was later removed by laparotomy following which the patient died of bronchopneumonia.

We now follow the rule and strongly urge that every common duct tube drain bile while the patient is on the operating table and if bile does not continue to drain the patient is returned to the operating table and a tube is

made to function. This should be done the day of the original operation in order to save the patient from the effects of bile spreading throughout the abdominal cavity. If one waits until the signs of bile peritonitis are apparent, the risk of fatal outcome is very great. In our series, 22 per cent succumb, while McLaughlin reports the mortality to be 2 or 3 times this figure.

The amount of daily bile drainage was tabulated not only to determine the average normal output and to determine the significance of output of large amounts but to find out the relation of the size and the type of drainage tube to this amount.

The most frequently used drainage tube was a No. 10 French whistle-tipped catheter and there was no apparent difference in the amount of bile drainage when the tip was placed up toward the liver or down toward the duodenum, although we believe that small ducts should have the catheter pointing toward the liver (1). The usual case with a smooth convalescence averaged 8 to 10 ounces of bile in 24 hours through a No. 10 catheter. More than 16 ounces in 1 day was unusual and an output of 18 ounces or more for more than 1 day invariably meant residual pathology. Larger catheters and T-tubes averaged 2 to 4 ounces more bile drainage daily. The position of the tube through the abdominal wall (stab or wound drainage) made no apparent difference in the amount of external biliary output.

When a No. 10 catheter was used and removed on the 10th day, biliary drainage practically always ceased within 48 hours and the wound was usually dry in 24 hours. With larger catheters, drainage was prolonged after removal and even more so after the use of a T-tube. The curves of postoperative hospital stay of patients in the Massachusetts General Hospital with catheter and T-tube drainage are shown in Graph 1. The average postoperative stay for patients drained with a catheter was 16.0 days and those with a T-tube 21.7 days. This difference is striking and seems to be chiefly due to prolonged drainage of bile following removal of the T-tube. However, wound sepsis also is an important factor as most of the T-tubes were brought out with

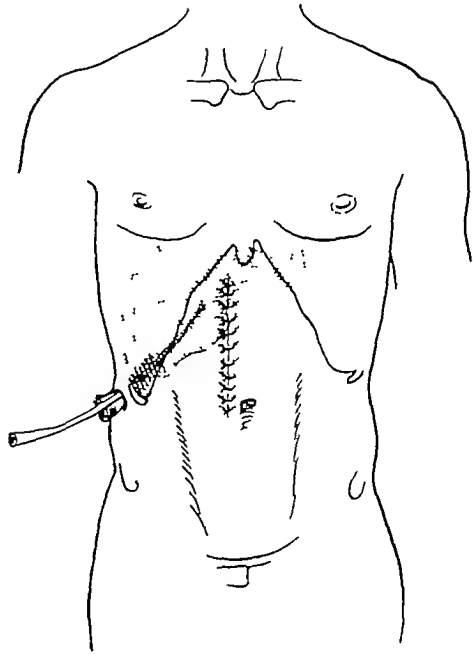


Fig. 3. Schematic drawing illustrating the final situation. The wick and the tube should be sutured to the skin with separate nonconstricting silk stitches.

the abdominal drain through the operative incision. It must be recorded that in a few instances, T-tubes were used when prolonged external drainage of the common duct was desired.

Anesthesia was used 4 times for the removal of a T-tube and in no instance for the removal of a catheter. We have felt that 10 days was a sufficient length of time for the tube to remain in the duct in those patients who have had careful graded dilatation of the papilla of Vater. We have removed the cigarette wick on the 10th day and the catheter as soon afterward as the No. 00 chromic catgut suture, holding it into the common duct, would let go. If a separate stitch is used for this fixation, the catheter comes away with greater ease than when the fixation stitch is a part of the continuous suture closing the incision in the duct.

Reaction following removal of the drainage wick occurred in 19 individuals, twice when a stab wound was used and 17 times when the wick was brought out through the operative wound. The average oral temperature elevation was 101.2 degrees. The chart was flat in

14 instances by 48 hours, 3 by 72 hours, and the remaining 2 by 96 hours. It would seem that the removal of a short dependent wick placed away from the operative field is followed by less reaction than is the longer one brought upward through the operative incision. The removal of the shorter wick also gives less discomfort to the patient. There are other logical reasons for using this short wick through a lateral incision directly into the subhepatic space. As Morrison originally pointed out, this is the fossa which collects the secretions from the field of operation. All fluid escaping from the right side of the water shed formed by the spinal column must gravitate to this region before it can escape either to the outside or into the various intra-abdominal areas. One may have the theoretical objection that a wick so placed would increase the danger of infecting the fluid carried above the liver by the effect of respiration. It seems to us that the early provision for escape of fluid as it collects, is actually a safeguard against an accumulation between the liver and the diaphragm.

As a matter of fact our data seem to indicate that adequate drainage to the outside is accomplished by the long wick introduced into the subhepatic fossa and brought out through the operative incision. This drainage is at first by capillary attraction and by the time this action is lost a sinus tract is established. One of our chief objections to the long wick is that with postoperative distention the drain sutured to the skin may well be lifted out of its dependent position. If this occurs, or if the wick is placed to the operative field disabling adhesions between the site of operation and the duodenum may occur.

We do not think one should use the lateral stab wound drainage in every instance. We have avoided its use in patients with a very thick abdominal wall. In such individuals, one is apt to find a wide flaring costal angle and these are best operated upon through some modification of the transverse approach. In secondary operation on the common duct, one is apt to find the subhepatic space oblit-

erated by adhesions which we believe should usually be left alone, thus making it more logical to bring out the drains through the operative incision. This is also true in cases of common duct repair especially if the repair is made over a T-tube. We have found it difficult to establish an external biliary fistula that does not follow the liver sulcus to the surface in the region of the attachment of the ligamentum teres.

#### SUMMARY AND CONCLUSIONS

When the common duct has been opened drainage through a suitable tube to the outside should be routinely established. Tight suture of the incision in the duct is difficult to accomplish.

Bile peritonitis carries a high mortality rate and can be greatly diminished by proper drainage of the region of operation.

Tubes should be functioning before the abdominal incision is closed. If function ceases, this should be corrected before the signs and symptoms of bile peritonitis are evident.

Whistle-tip catheters are adequate for drainage of the common duct, particularly if the papilla of Vater has been gradually dilated to 7 millimeters. This type of tube should be pointed toward the liver if the duct is small, since the open end will allow for easier escape of bile through the tube. Such a tube can be removed without injuring the suture line in the duct, and there is a minimal amount of drainage after its removal.

In the average case with a vertical paramedian incision, one may reduce the morbidity caused by wound infection, dehiscence and hernia in scar by providing a carefully placed lateral stab wound through which the drains may be brought.

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# ILEUS ASSOCIATED WITH EDEMA OF THE BOWEL

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ATTENTION was directed to the problem of ileus associated with edema of the bowel by a small group of cases in the so called paralytic obstructions in which the Miller-Abbott tube failed to pass along the small bowel at the usual rate of speed. Abbott had previously observed a patient in the uremic state with abdominal distention who failed to advance the tube. This was apparently caused by the depressed motor activity of the small bowel.

In the series of cases with acute intestinal obstruction reported by McIver from the Massachusetts General Hospital between 1918-1927, inclusive, 9 were classified as functional obstructions because no recognizable pathology was found at autopsy. These cases occurred in the very young or aged patients, and the functional disturbance of the bowel was attributed to their poor constitutional state.

Jones and Eaton discuss the effect of edema on the gastrointestinal activity in their report on postoperative nutritional edema observed in a variety of surgical patients. The factors responsible for the edema, mainly the low plasma protein concentration because of preoperative starvation and excess intravenous saline after operation, were fully appreciated by these authors.

Ravdin and his coworkers (9, 10, 11) pursued the problem further and demonstrated that the gastric emptying time, as measured by the water barium meal, was prolonged in dogs and patients when the serum protein concentration was lowered. This fact was true in both the intact stomach and after shortcircuiting operations.

In further studies by this group (Borden, Thompson, Ravdin and Frank(4)), the small bowel emptying time of dogs was seen to in-

crease as the serum protein concentration was reduced by repeated plasmapheresis.

Of the cases of small bowel obstructions at the Presbyterian Hospital during the past 4 years, a group of 51 cases was classified as "paralytic" because the Miller-Abbott tube failed to demonstrate a mechanical obstruction during the process of deflation. Paralysis or inhibition of normal bowel motility was apparent in a few cases with known lesions of the spinal cord and retroperitoneal space. The Miller-Abbott tube advanced slowly along the bowel in the process of deflation, and repeated daily studies with barium injected through the tube showed only dilated loops of atonic bowel distal to the advancing tip of the tube (Table I). Seventeen cases associated with edema also exhibited this marked depression or inhibition of small bowel activity. These cases, associated with edema of the bowel, required an average of 6.2 days to advance the Miller-Abbott tube along the entire length of the small bowel. In contrast, 26 cases attrib-

TABLE I —SMALL BOWEL OBSTRUCTIONS—  
PARALYTIC TYPE

Cause of obstruction	Number of cases	Total	Average time for Miller Abbott tube to traverse small bowel—days
Spinal cord lesions		3	12
Ascending transverse myelitis	2		
After spinal pontocaine	1		
Retroperitoneal lesions		3	5.4
Hemorrhage from abdominal aneurysm	1		
Traumatic rupture of ureter	1		1
Operative trauma and hemorrhage	1		
Associated with edema of the bowel		17	6.2
After gastrointestinal surgery	10		
Liver disease	2		
Nutritional deficiencies	2		
Uremia due to renal failure	2		
Extensive cutaneous burns	1		
Operative trauma		26	2.1
After extensive pelvic surgery	17		
After abdominal explorations	4		
After resections of colon or rectum	5		
Bronchopneumonia		2	2.5
Total cases		51	

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Read before the Forum on Fundamental Surgical Problems at the Clinical Congress of the American College of Surgeons, Boston, Massachusetts, November 7, 1941.

Aided by a grant from the Josiah Macy Jr. Foundation.



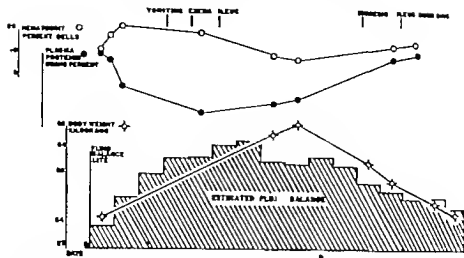


Chart. The typical course of the changes in the plasma protein concentration, hematocrit, and total body weight during the development of ileus associated with edema of the bowel following an extensive cutaneous burn.

uted to operative trauma required an average of only 2 1/2 days to pass the tube into the cecum.

The typical cases in the group associated with edema of the bowel were similar to the cases stressed by Ravdin and Rhoades (10) and Jones and Eaton in gastric cases. Ravdin's statement that 'too much emphasis has been placed on the water and salt replacement of the surgical cases and too little on the mechanism involved in keeping the fluids within the blood vessels' is well demonstrated in these cases.

#### ILLUSTRATIVE CASES

**CASE 1.** Male, aged 5 years (Chart 1) with extensive cutaneous burns who was under detailed study for changes in fluid distribution. The estimated positive fluid balance in these charts is calculated by subtracting the total fluid output (urine and vomitus) plus an additional 500 cubic centimeters daily for insensible fluid loss from the total fluid intake. These figures parallel fairly well the actual changes observed in the total body weight. It may be seen that there was a gain in body weight of over 8 kilograms during the first 6 hospital days. The typical rapid fall in plasma protein concentration accompanied by a rapid rise in the hematocrit was observed during the first few days. Weech, and Drew Scudder and Pappas have emphasized that this type of blood picture will not prevent edema formation even in the presence of hemoconcentration. When vomiting begins, the usual treatment is directed to water and salt replacement which of course only increases the edema (Beard and Blalock).

The abdominal roentgenograms (Fig. 1) in this case (and in others in this group) showed the typical picture of ileus with dilated loops of small bowel with fluid level formation in the lateral decubitus positions. Small bowel intubation started on the 6th hospital day relieved the symptoms of nausea and vomiting, but the tip advanced only a few feet during the next days. All intravenous therapy was discontinued except plasma. The Miller-Abbott tube passed rapidly into the transverse colon during the next hours as diarrhea began and distention disappeared.

**CASE 2 (Chart 2).** A female aged 63 showed the same typical picture following a partial colectomy for carcinoma of the sigmoid. Twenty liters of normal saline were administered during the 5 days following operation. Increasing abdominal distention and vomiting began on the 3d postoperative day. A low plasma protein concentration and high hematocrit were found at this time. Several whole blood transfusions during the next 2 days failed to reverse the distention or cause a diarrhea. A rectoscopy done on the 5th postoperative day failed to function. 7 liters of ascitic fluid were present at the second operation, and the bowel was described as edematous. Small bowel intubation started on the evening of the 7th postoperative day delivered 7 liters of fluid from the upper gastrointestinal tract during the next 36 hours. Six additional days were required for the Miller-Abbott tube to reach the cecum. At this time mild diarrhea began, and the normal bowel function was re-established.

The abdominal roentgenograms (Fig. 2) illustrate the chief difficulty encountered in these cases. The tip of the Miller-Abbott tube can be easily passed into the duodenum with-

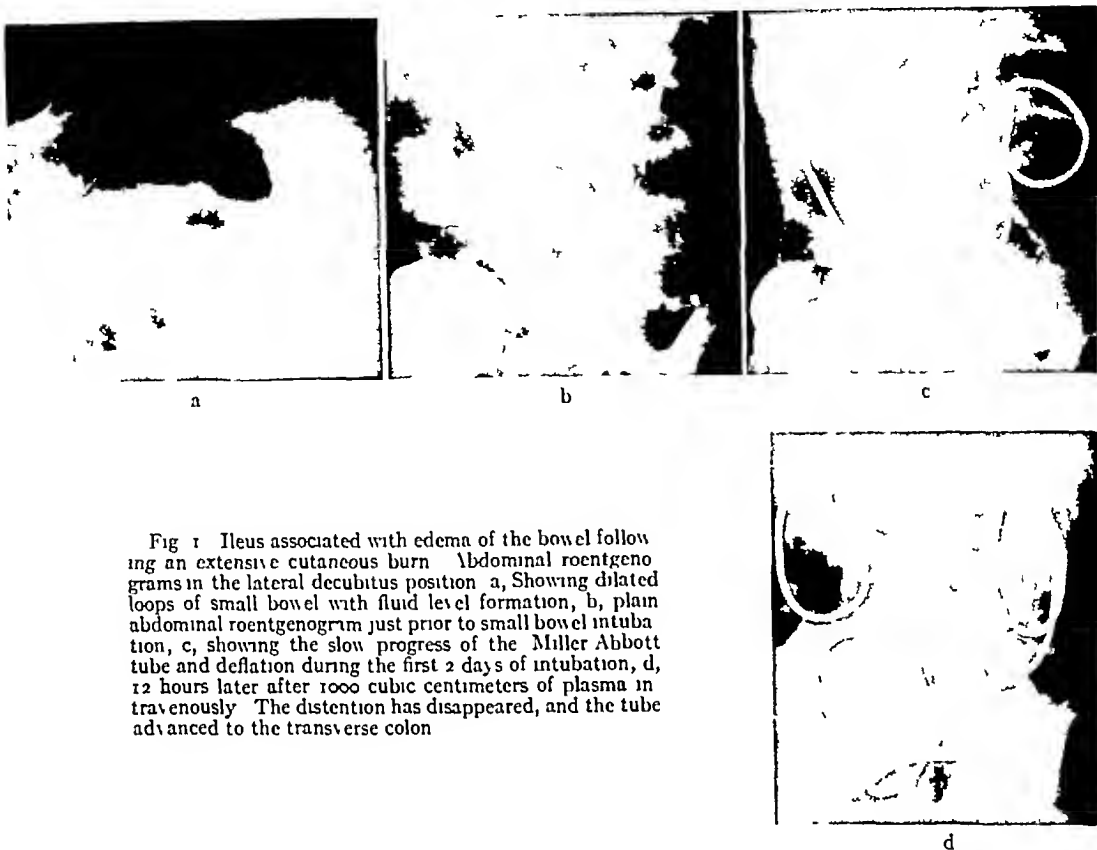


Fig 1 Ileus associated with edema of the bowel following an extensive cutaneous burn. Abdominal roentgenograms in the lateral decubitus position a, Showing dilated loops of small bowel with fluid level formation, b, plain abdominal roentgenogram just prior to small bowel intubation, c, showing the slow progress of the Miller Abbott tube and deflation during the first 2 days of intubation, d, 12 hours later after 1000 cubic centimeters of plasma intravenously. The distention has disappeared, and the tube advanced to the transverse colon.

out the usual difficulty encountered at the pylorus in cases with obstructions. After the balloon has been inflated in the duodenum, having passed the pylorus, the tube is usually fed into the stomach at the rate of approximately 6 inches every 1 or 2 hours. In these cases, however, the tip fails to advance at the usual rate of speed and the excess tubing accumulates in the stomach or prolapses extra loops into the duodenum (Fig 2b). This may cause sharp angulations in the tube which occlude the lumen and interfere with suction.

#### EXPERIMENTAL

In acute experiments on 4 normal dogs we have observations that support the results reported by Borden and his coworkers (4) from prolonged studies on dogs with reduced plasma protein concentration (Chart 3). Motility in the small bowel was recorded from a balloon attached to a water manometer. As the

plasma proteins were rapidly depleted by plasmapheresis and by the injection of additional normal saline, both the tone and peristaltic activity of the small bowel were depressed. In these experiments the hematocrit and blood pressure were maintained at almost normal levels although the heart rate was usually increased.

It should be emphasized that this method of studying small bowel activity will give misleading results unless done carefully. The balloon must be inflated for only a short period of time and with only small amounts of air. Otherwise edema of the bowel will result even in the normal dog. Furthermore, the injection of saline or rapid bleeding may cause a momentary increase in the motor activity of the bowel.

In the clinical cases (Table I) gross edema of the bowel was described either at operation or at proctoscopic examination. In the acute

is caused by the low plasma protein concentration and by excess intravenous saline rather than being the result of lymph stasis on the basis of operative trauma and consequent inactivity of the small bowel.

We are purposely avoiding a discussion of the factors responsible for the gaseous distention in these cases. It is a well known fact that many patients with widespread edema of the bowel and undoubtedly marked depression of intestinal activity have only mild difficulty from gaseous distention of the bowel. The important fact for the surgeon to note is that true inhibition of the motor activity of the bowel is present in only two types of cases: those associated with lesions of the spinal cord or retroperitoneal space and those accompanied by edema of the bowel. In the latter group rapid deflation can be accomplished by ridding the bowel of edema and restoring small intestinal activity.

#### CONCLUSIONS

Small bowel motility has been found markedly depressed in cases with ileus associated with edema of the bowel.

In most cases the edema appeared to aggravate existing partial mechanical obstructions of the bowel (Case 2). In a few cases the edema

was the only known etiological factor present (Case 1).

Therapy directed to fluid and salt replacement will increase the edema as long as the plasma protein concentration remains at edema level.

Therapy directed toward raising the plasma protein concentration will restore small bowel activity and aid in the deflation of the patient.

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# INSULT TO THE TESTICLE IN HERNIORRHAPHY

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OF the last hundred patients operated upon for inguinal hernia at The Mason Clinic, we have had but two who developed immediate detectable, postoperative testicular swelling. These cases are reported herewith as it is believed that their course and treatment may be instructive. That we have been fortunate is suggested by comparison with the carefully reported series of 150 patients operated on for inguinal hernia at Lahey Clinic (1), 6.7 per cent of whom developed shortly after operation some evidence of atrophy of the testicle on the side operated upon. There had been no previous disorder in any of these organs.

In a study of the case histories of 1,093 patients operated on for inguinal hernia, Erdman found an incidence of 13.1 per cent of postoperative tumefactions in the scrotum. In his series, 4.6 per cent developed early hydroceles which contained from 20 to 60 cubic centimeters of clear yellow fluid. Outside the hydroceles, this author classified other tumefactions as distention of the veins in the pampiniform plexus, thrombosed veins, thickening of the tunica, hematomas, and epididymo-orchitis. It is interesting to observe that the majority of those classified as hematomas and epididymo-orchitis subsequently developed atrophy of the testicle. In this group, 11 patients, or 1 per cent, complained of pain in the groin or scrotum for a period of from 3 months to 2½ years, and the author believes that one-half of these probably had nerve involvement as the etiological factor. Of these, 1.5 per cent developed postoperative atrophy of the testicle.

In a series of 1,500 cases, Huston found only 3 which showed evidence of postoperative atrophy of the testicle. These were observed early in the series, before his operative technique was modified to give less compression to the cord. The literature contains reports of cases of frank necrosis of the testicle following herniorrhaphy, and even operation on and

about the neck of the urinary bladder in some instances has been followed by gangrene of the testicle.

Many statistical follow-ups on inguinal herniorrhaphies mention the most remote complications yet fail even to consider damage sustained by the testicle.

## PSYCHIC EFFECT

The occurrence of any complication that involves the genital organs or even their immediate vicinity has a particularly devastating effect upon the morale of the patient. In the male, painful or swollen testicles, atrophy of the organ, discoloration of the scrotal skin, tumefaction of the scrotum and numbness of the skin of the scrotum, medial thigh, or pubic region create mental unrest in those unacquainted with the nature of the condition. This is especially true of the younger adult whose apprehension of sterility or even impotence may be deep in his mind. It is strange how readily even an extragenital complication may be interpreted as a probable cause for impaired or lost sexual function. The surgeon must be aware of this fact, though the very nature of the patient's concern is such that he makes little or no mention of it.

## ANATOMY

Familiarity with the structures in and around the inguinal canal is required for appreciation and understanding of the sequelae of hernial repair.

The arterial supply to the testicle comes almost exclusively from the internal spermatic vessel in the cord. A small branch of the deep epigastric artery passes through the canal, as does a division of the (vas) deferential artery, but the supply of blood to the testicle by these channels is negligible. Any process which occludes the spermatic artery will certainly involve these smaller vessels. The venous return courses, for the most part, in the pampiniform plexus about the cord.

is caused by the low plasma protein concentration and by excess intravenous saline rather than being the result of lymph stasis on the basis of operative trauma and consequent inactivity of the small bowel.

We are purposely avoiding a discussion of the factors responsible for the gaseous distention in these cases. It is a well known fact that many patients with widespread edema of the bowel and undoubtedly marked depression of intestinal activity have only mild difficulty from gaseous distention of the bowel. The important fact for the surgeon to note is that true inhibition of the motor activity of the bowel is present in only two types of cases: those associated with lesions of the spinal cord or retroperitoneal space and those accompanied by edema of the bowel. In the latter group rapid deflation can be accomplished by ridding the bowel of edema and restoring small intestinal activity.

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tual amount of swelling of a testicle, or the length of time that any degree of enlargement could be allowed to continue, with a prognosis as to permanent damage to the testicle

#### TREATMENT

Very little can be found in the literature on the surgical procedure for preventing postoperative atrophy of the testicle. Measures have been proposed to relieve the tension developing in the orchitis of mumps.

The treatment is first of all preventive, and, in herniorrhaphy, the requisites for this are the establishment of an adequate sized aperture for the passage of the cord, reduction of the bulk of the cord (Halsted), and minimizing the trauma to the tissues. Careless reduction of the bulk of the cord has been reported as a probable cause for postoperative atrophy of the testicle.

Curative treatment must aim at exploration of the repair and widening of the passageway for the cord or at dividing the capsule of the testicle to forestall possible pressure necrosis. This latter method was our choice in 1 of our 2 cases when the testicle had enlarged painlessly to a size one and one-half times its normal 24 hours after operation.

As to the technique of incising the capsule, we used a straight incision from pole to pole on the exposed surface of the organ (Fig 1). This method insures the greatest possible relief of capsular restraint. The immediate evagination of the parenchyma as the incision is made, we feel, is an argument for, rather than against, this method. Multiple slit incisions have been used by others (Ballenger, Smith, and Elder in the publications already quoted), and in this way they release much of the internal pressure and still retain capsular tissue throughout. Hot wet packs are applied after the closure, and we used one small Penrose drain in the incision. In our case, local infiltration anesthesia was used with satisfactory results.

#### CASE REPORTS

W. C. (No. A 52028), aged 40 years, entered the Clinic October 4, 1938, with a history of having noticed a rather severe strain in both groins while playing golf a few days before his entrance. Physical examination showed bilateral inguinal hernias which were shown at surgery to be direct.

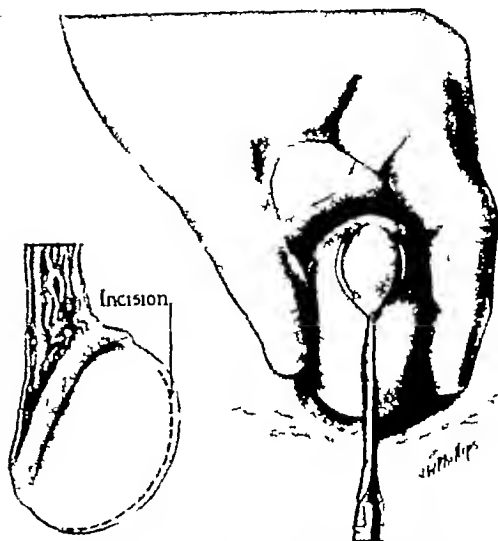


Fig 1. A continuous straight incision from pole to pole is made. The site of choice is directly opposite to the root of the organ.

A modified Bassini herniorrhaphy was done on each side, and fascial transplants were employed to bind the conjoined tendon and internal oblique muscle to the shelving edge of Poupart's ligament. The patient developed an upper respiratory infection and was troubled with gas pains. About 12 hours after operation, swelling of the right testicle was noticed. The testicle enlarged to one and one-half times its former size. Two months later, atrophy of the organ was observed, and in 4 months, it was no more than 1.5 centimeters in diameter.

L. R. (No. A 15051), aged 47 years, came to the Clinic September 24, 1940, with a history of having noticed pain in the right groin upon coughing 4 days before.

Physical examination showed a right indirect inguinal hernia, 3 centimeters in size, which was reducible. The left inguinal region was normal. Two months later, a Bassini herniorrhaphy was done. A "pantaloon" was encountered, and the herniated sac was seen to be of the direct type.

Repeated observations during the following 24 hours showed progressive, painless enlargement of the testicle, and at the end of this 24 hour period operative intervention was decided upon. Incision of the capsule, as described, was done. Further scrotal swelling and discoloration ensued. The swelling had subsided appreciably at the end of 2 weeks. Subsequent examination at the end of 6 weeks showed no evident enlargement of the scrotum or testicle. Convalescence was otherwise uneventful, and a low grade fever that had been present with the postoperative swelling quickly subsided.

Examination of this man 2 years later showed no discernible abnormality of the involved testicle de-

Running with the cord in the canal are two nerves, chiefly sensory namely the ilioinguinal and external spermatic nerves. The ilioinguinal nerve supplies the skin of the upper medial part of the thigh and the root of the penis and scrotum. A few fibers of this nerve supplying part of the internal oblique muscle usually split from the main bundle far enough proximally to be out of the field of danger. The external spermatic is a branch of the genitofemoral nerve, and besides giving motor fibers to the cremasteric muscle supplies sensory fibers to part of the skin of the scrotum. Just above the inguinal canal and running parallel to it, beneath the aponeurosis of the external oblique is the anterior cutaneous branch of the iliohypogastric nerve. Destruction of this leaves an anesthetic area of skin on that side superior and lateral to the symphysis pubis.

#### PATHOLOGY

The most common disorder of the testicle following inguinal herniorrhaphy is passive congestion from obstructed venous return. It is strange, but unfortunate for the surgeon that the reactions of the tissues, in different subjects vary with identical operative procedures. In some even with most gentle manipulation, local vasoconstriction is marked and there is probable circulatory embarrassment to the parts supplied and drained while in other subjects, necessary vigorous manipulation leaves no demonstrable after-effects.

Passive congestion of the testicle can be responsible for the following conditions:

1. Dilatation of the veins in the pampiniform plexus.
2. Hydrocele from passive transudation.
3. Lowered tissue resistance and, hence active infection from a dormant local condition or a circulating organism that ordinarily would not find such a favorable medium.

4. Lastly but most important, from our viewpoint, an increased intratesticular tension which may become severe enough to cause pressure necrosis of the parenchyma and ultimate atrophy of the testicle. It is hard to believe that passive congestion alone can cause this unless the venous return is blocked completely. The most likely explanation in our

opinion is that tension sufficient to enlarge the testicle is the result of passive congestion plus a subacute inflammatory process. Under ordinary circumstances, exudation produces much more tension than pure transudation. This belief is well supported by the observation of Erdman that those cases that went on to atrophy had been diagnosed either as epididymo-orchitis or hematoma.

Hertzer in his monograph on the surgical pathology of the genitourinary organs, states that the four most common causes of atrophy of the testicle are mumps, herniorrhaphy, trauma, and varicocele.

In an interesting study of circulatory changes in the testicle by Iwasita, the following observations, with rabbits and dogs as subjects, were made:

A. With complete occlusion of all of the spermatic veins and release after 24 hours, study of the tissue of the testicle showed slight passive congestion, and 5 days after the return of the circulation, there was proliferation of the interstitium with slight hemorrhagic infarction, but the parenchyma was only slightly altered after this temporary congestion.

B. After occlusion of the veins and vas deferens at the same time and release of the ligature in 24 hours, slight necrosis of the parenchyma, interstitial hemorrhage and moderate dilatation of the veins were found, and 5 days later the testicle showed complete hemorrhagic infarction.

C. When all the structures of the cord were tied off for a period of 5 hours and then released there was practically no destruction to be found in the testicle after 18 days.

D. When all the structures of the cord had been ligated for a period of 10 hours and then released, complete degeneration of the parenchyma and fibrous proliferation throughout was noted in sections of the testicle 45 days later.

Viewed in the light of the knowledge gained by the aforementioned experimental work, it behooves us to keep careful watch for post-operative swelling and to institute treatment promptly when the integrity of a testicle is threatened. We could find no report of investigation as to the relation between the ac-

tual amount of swelling of a testicle, or the length of time that any degree of enlargement could be allowed to continue, with a prognosis as to permanent damage to the testicle

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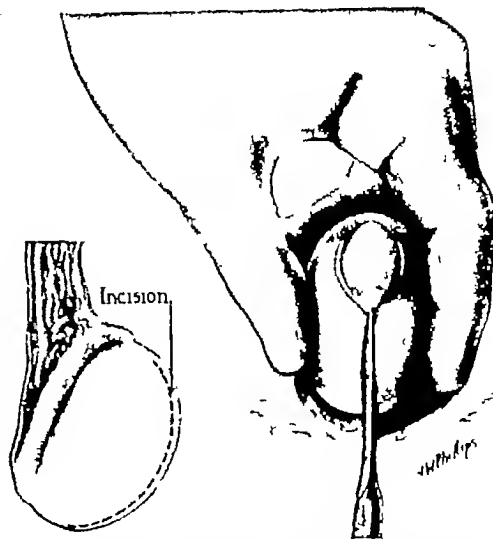


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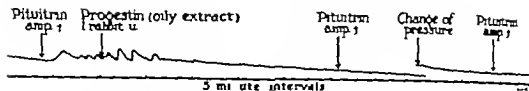


Fig. Contractions stimulated by pituitrin, stopped by rabbit uak of progesterin

ever is open to a certain amount of criticism because of the subjective character of the evidence presented. Nor do the results obtained from the use of a preparation in laboratory animal experiments convince a critical judge of its efficacy when used on the human. It was not until the action of corpus luteum preparations in stopping uterine contractions which had been induced by the injection of posterior lobe pituitary extracts in animals by Novak and Reynolds, and in human subjects by Falls, Lackner and Krohn had been clearly demonstrated by the intrauterine bag method of Moir that the usefulness of these preparations in the treatment of abortion was established beyond any reasonable doubt.

Since demonstrating the pharmacological potency of these preparations in combating uterine contractions in human beings, and in order to convince ourselves that the clinical results obtained by Falls, Lackner and Krohn in a series of 41 cases were not accidental, we have used it in a rather large series of cases at the Research and Educational Hospital, the Cook County Hospital, and in our private practice. The results obtained have been gratifying and confirmed our previous clinical impressions. Various preparations containing corpus luteum extracts have been used and their potency tested clinically as well as pharmacologically. We have thus obtained first hand information regarding the therapeutic potency of a considerable number of the preparations on the market. As might be expected a considerable difference in the activity of these preparations in inhibiting uterine con-

tractions was noted. This probably explains the difference of opinion of certain observers regarding their clinical usefulness in the treatment of abortion.

In the last few years we have been especially concerned with the application of these preparations to the solution of other obstetrical problems dependent upon the contractility of the uterus. The principal conditions that we wish to discuss under this heading are placenta previa, premature detachment of the placenta, premature rupture of the membranes, and premature labor. Our observations have led us to believe that the use of corpus luteum extract injections at the proper time, the proper dose being used in all of these conditions, is of considerable value and marks the first attempt to correct the etiological factor concerned with the development of these serious obstetrical complications.

One of the next problems which caused difficulty in the clinical application of the hormone was the cost of production which made its use prohibitive for all but wealthy patients, when the treatment had to be continued for any considerable length of time. In searching for an answer to this problem, we decided to assay a water soluble corpus luteum extract which has been in general use for years. In spite of the fact that the hormones were thought to be contained only in oil extracts of corpora lutea, we were able to demonstrate that some aqueous preparations stopped uterine contractions induced by posterior hypophysis extract injections. We have found that by using this material during

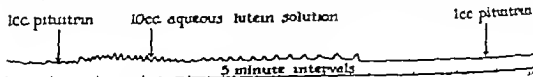


Fig. Complete inhibition of pituitrin action by cubic centimeters of lutein

1cc pituitrin 5cc aqueous lutein solution

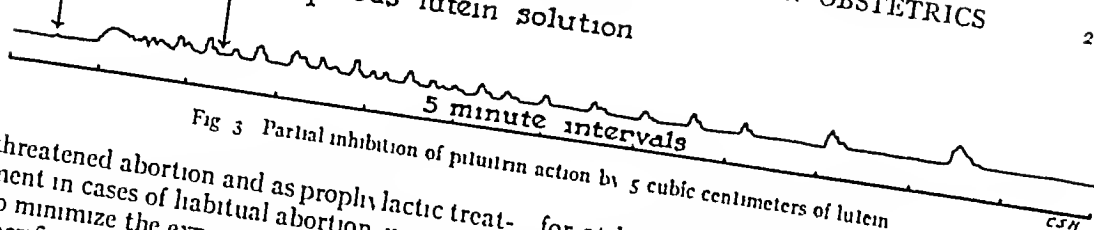


Fig 3 Partial inhibition of pituitrin action by 5 cubic centimeters of lutein

threatened abortion and as prophylactic treatment in cases of habitual abortion, we are able to minimize the expense of treatment without sacrificing safety. The aqueous solutions have the added advantage that they may be used intravenously in an emergency.

In order to obtain further information on the clinical value of corpus luteum extract in patients with threatened and habitual abortion, we have used an aqueous preparation<sup>1</sup> at the Cook County Hospital in the treatment of indigent patients entering this institution. The principles of management were the same as those laid down for our earlier work, and the management of the cases was closely followed by one of us (Dr Benensohn). The work has been carried on now for a period of 2 years. A total of 272 cases have been treated, of these 217 could be classified as threatened abortion, and 59 as habitual abortion. An additional 59 cases were treated but not included in the series because the status of the pregnancy was unknown at the time the patient left the hospital or subsequently. The results can be seen in Tables I and II and Figures 1 and 2.

In the failure group the diagnosis was dependent upon gross or microscopic evidence of expelled products of conception. The routine of therapy instituted consisted of 3 cubic centimeters of aqueous corpus luteum extract administered intramuscularly every 4 hours for 6 doses, then 3 times per day for 2 days following which the dose was reduced to 2 cubic centimeters twice daily until discharged. The patient was required to be up and about

<sup>1</sup>Lutein ampuls—a sterile aqueous extract of corpus luteum

1cc Pituitrin

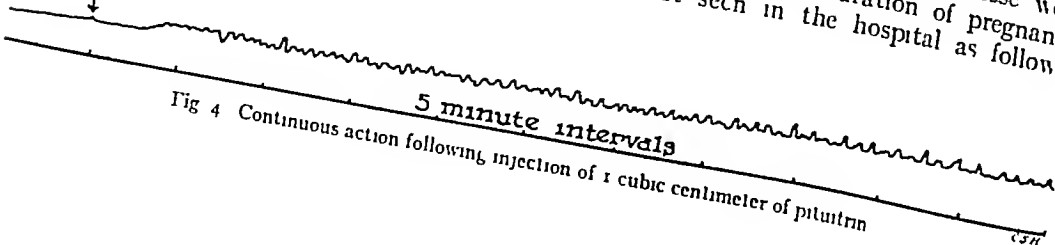


Fig 4 Continuous action following injection of 1 cubic centimeter of pituitrin

for at least 2 days without bleeding, and free from pain before being discharged from the hospital. After discharge from the hospital, the treated patients were referred to the clinic for continuation of therapy and were instructed to return to the hospital if bleeding or pain suggested a recurrence of a threatened abortion. Thus 65 cases herein presented were followed in the clinic. The remainder are known to have delivered viable pregnancies either at the Cook County Hospital or by other local institutions.

**Comments on failures.** Seventeen patients aborted while in the hospital despite large doses of aqueous corpus luteum extract, while in 2 cases only 6 cubic centimeters were administered. Three of these patients delivered macerated fetuses. Four patients aborted after discharge from the hospital. Three patients, 1 a diabetic, returned to the hospital as inevitable or incomplete abortions, and 1 patient expelled a dead 7 month previable fetus at home after being discharged from the hospital following 2 weeks

Although the number of days of therapy is an excellent criterion of the amount of therapy necessary, it is noteworthy that in 91 of the 189 patients treated all bleeding and cramps subsided after receiving between 6 cubic centimeters and 9 cubic centimeters of aqueous corpus luteum extract.

**Control series.** There were 88 cases in which a diagnosis of threatened abortion was made on admission to the hospital. These were tabulated as to the duration of pregnancy when first seen in the hospital as follows

TABLE I.—THREATENED ABORTION IN WOMEN WITH HISTORY OF HABITUAL ABORTION—189 SUCCESSES, 28 FAILURES

Duration of pregnancy when pain, bleeding or both began	1-2 mos.	3 mos.	4 mos.	5 mos.	6-9 mos.	Total
	18		24	26	27	189
Amount of treatment based on hospital days	1-2 mos.	3 mos.	4 mos.	5 mos.	6-9 mos.	
	23	24	42	26	23	139
Failures—duration of pregnancy	1-2 mos.	3 mos.	4 mos.	5 mos.	6-9 mos.	
	6		2			28
Per cent success	83.5					

Under 3 months, 44 3 months to 18 weeks 23 18 weeks to viability 22

Therapy instituted in this series consisted of rest in bed icebag to the abdomen barbiturates or in some cases, morphine sulphate. However if the cases progressed to an inevitable abortion, quinine and pituitrin were administered in an attempt to hasten delivery. In this entire series 55 patients 61 per cent, completed the abortion 33 cases 39 per cent, were discharged from the hospital as still pregnant. Of the 55 patients that had aborted, only 6 pregnancies were beyond 18 weeks 12 were estimated to be from 12 to 18 weeks pregnant and 37 were pregnant less than 12 weeks.

In comparing the results in the 3 month period on corpus luteum extract, there were 15 failures in 112 cases, whereas, in the control group there were 37 failures in 44 cases.

The second series of cases (Table II) were cases of habitual abortion. All patients who

TABLE III.—RESEARCH AND EDUCATIONAL HOSPITAL—THREATENED ABORTIONS

Duration of pregnancy when pain, bleeding or both began	1-2 mos.	3 mos.	4 mos.	5 mos.	6-9 mos.	Total
	42	20	26	27	60	175
Amount of treatment based on hospital days	1-2 mos.	3 mos.	4 mos.	5 mos.	6-9 mos.	
	47	20	23	26	20	
Failures—duration of pregnancy	1-2 mos.	3 mos.	4 mos.	5 mos.	6-9 mos.	
	8					28
Per cent success	86.4					

gave a history of two or more abortions were placed in this group. Also cases with a history of one abortion but who in their present pregnancy presented a picture of threatened abortion such as spotting and cramp-like pains were also included in this group. Thus, 59 cases were placed in this group. Therapy consisted in most cases of at least 2½ cubic centimeters of aqueous corpus luteum extract two times per week. However some of these patients did not appear for treatment but once a week. There were 51 successes and 8 failures.

During the same time we have treated at the Research and Educational Hospital and in our private practices 454 cases of which 233 were threatened abortions and 100 were habitual abortions. The results obtained in this group are shown in Tables III IV V and VI.

It would seem then that in our hands, satisfactory results can be obtained in approximately 85 per cent of the cases even though the County Hospital and Research and Edu-

TABLE II.—HABITUAL ABORTION—51 SUCCESS 8 FAILURES

% of previous spontaneous abortions	1st term	2nd term	3rd term	4th term	or more	Total
	18	20				38
Duration of pregnancy when treatment started	1-2 mos.	3 mos.	4 mos.	5 mos.	6-9 mos.	
	23			23		23
Amount of treatment—cubic centimeters	1-2 mos.	3 mos.	4 mos.	5 mos.	6-9 mos.	
	26	20	20	20	20	23
Failures—amount of treatment	1-2 mos.	3 mos.	4 mos.	5 mos.	6-9 mos.	
	2					2

TABLE IV.—HABITUAL ABORTIONS

Number of previous spontaneous abortions	1st term	2nd term	3rd term	4th term	5th term	6-9 mos.	over 10	Total
	20			5				25
Duration of pregnancy when treatment started	1-2 mos.	3 mos.	4 mos.	5 mos.	6 mos.			
	12		20					32
Number of 2 in 100 cases given	1-2 mos.	3 mos.	4 mos.	5 mos.	6 mos.	over 10		
	20	5	20	20	20			85
Failures based on amount of treatment								

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TABLE V — THREATENED ABORTIONS—PRIVATE CASES

Duration of pregnancy when pain bleeding or both began	1-2 mos	3 mos	4 mos	5 mos	6-7 mos	Total
Amount of treatment based on days in bed	2 mos	20	5	5	5	51
Failures—duration of pregnancy	1-2 mos	3 mos	4 mos	5 mos	6-7 mos	51
Per cent earned successfully to viability	3	2	2		1	8

TABLE VI — HABITUAL ABORTIONS—PRIVATE CASES

Number of previous spontaneous abortions	1 abortion	2 abortions	3 abortions	4 abortions	5 abortions	6-10 abortions	over 10	Total
Duration of pregnancy when treatment started	1-2 mos	1 mos	4 mos	5 mos	6 mos		2	51
Number of sec. infections given	5-9 am puls	10-10 am puls	20-20 am puls	10-10 am puls	over 50			51
Failures based on amount of treatment		4	5	10	24			51

educational Hospital patients for various reasons do not co-operate in a study of this kind as well as they might if they were a little higher in the economic and intellectual scale. No patient was admitted to these services unless definite evidence of threatened abortion was present, including a history of amenorrhea, bleeding, uterine contractions, and a positive Friedman test. To be considered successfully treated, the patient must have delivered a viable baby who left the hospital alive not under 7 days.

The routine of therapy instituted at Research and Educational Hospital and private practice consisted of injections of 3 cubic centimeters of aqueous corpus luteum extract every 4 hours for the cases of threatened abortion during the active bleeding or cramping period in addition to absolute bed rest. After symptoms of bleeding and pain subsided, patients were given 3 cubic centimeters daily for 5 to 7 days, and then 3 cubic centimeters twice a week until viability was reached. Home bed confined patients were given 12 cubic centimeters of aqueous corpus luteum extracts intravenously daily during cramping and bleeding period to reduce the number of house calls. Further treatment was as mentioned.

The habitual abortion group was treated by the injection intramuscularly of 3 cubic centimeters twice a week. Treatment was started as soon as diagnosis of habitual abortion was made. Patients who had previously spontaneously aborted were placed in this group. The group of patients consisting of placenta previa, premature detachment of the placenta

and premature rupture of the membranes were treated in a similar manner to the threatened abortion cases.

In the management of obstetrical complications closely resembling abortion, such as premature onset of labor with or without the rupture of the membranes, it seemed likely that the use of aqueous corpus luteum extracts to inhibit uterine contractions might be valuable in retaining the fetus *in utero* at least until the age of viability. We have treated 8 patients with premature rupture of the membranes at various stages of pregnancy. We have been able to keep some of these women from going into labor for weeks or even months in a few cases. In such cases there is always the danger that the liquor amni will become contaminated by the bacteria in the vagina and that these organisms will spread to the placenta and to the fetus. With the development of fever in such cases the uterus usually develops strong contractions which cannot be controlled by these injections. It would not be good judgment to prevent them

TABLE VII — MISCELLANEOUS USES OF LUTEIN

Conditions	Number of cases treated	Failures	Per cent terminating successfully
Premature separation of placenta	46		
Placenta previa	18	4	91
Patients subjected to laparotomy during pregnancy	29	1	94.5
Premature rupture of membranes	8	0	100
		1	87

even if it were possible. Accordingly as soon as such patients give any evidence of infection the corpus luteum extract injections are stopped and the uterus is encouraged to empty itself. Table VII shows the result of our treatment in these cases.

In the 46 cases of premature separation of the placenta, 26 had had bleeding upon more than one occasion before the pregnancy terminated successfully. Four patients had 4 periods of moderate bleeding, one of whom did not carry through to viability but delivered a 1050 gram baby that died 3 hours after delivery. Much the same was experienced in the placenta previa cases. In this series of 18 cases, 10 had more than 1 period of bleeding and 1 case had 4, before pregnancy terminated successfully by cesarean section—the baby weighed 1820 grams and left the hospital 3 weeks later weighing 2540 grams. In all the cases of premature separation of the placenta, old adherent clots were found on the placenta at the site of separation and in those that were terminated by cesarean section many old clots were found in the uterus.

In the cases of placenta previa, diagnosis was confirmed after delivery by finding the placenta over the cervical os during the cesarean section or in the cases that delivered vaginally by the marginal rupture of membranes and partial compression of the placenta. The average duration of time that the delivery of the baby was delayed was 36 days in both above series. The longest time that delivery was delayed was 57 days. These additional days *in utero* for the fetus meant the difference between a previable fetus and a viable fetus at the time of delivery.

In the series of 8 cases in which the membranes ruptured prematurely the delivery was delayed an average of 8½ weeks following the administration of aqueous corpus luteum extract. The longest time that labor was delayed was 5 months. This case threatened to abort three times during the 5 months. Each time abortion threatened the amount of aqueous corpus luteum extract given daily was increased until the symptoms of pain and bleeding subsided and then the dosage was reduced to maintenance. The patient delivered a 4½ pound baby at 8½ lunar months. The fetus

was in no way deformed from the lack of cushioning effect of the amniotic fluid. The child at present is 2 years old and normal in every respect. Another labor was delayed 3½ months after the rupture of the membranes, 2 were delayed 8 weeks, one 6 weeks, one 5 weeks, and two 4 weeks. In all probability the added weeks *in utero* gave the fetus a definite advantage in surviving after delivery.

In the 29 cases upon which it was necessary to perform major surgery no cases aborted. In this series there were 10 appendectomies, 9 operations for ovarian cysts, 5 myomectomies, and in 2 cases it was necessary to replace the uterus to its normal position following an interposition operation, done elsewhere, without sterilization. In 3 cases the abdomen was opened by mistake because the operator suspected fibroids whereas the uterus was found to be pregnant. It has been found to be advantageous to start the corpus luteum treatment as soon as surgery is contemplated and to continue after surgery. However in emergency appendectomies results were excellent where it was necessary to give practically all treatment after operation.

Premature labor without rupture of the membranes occurs frequently and is often an unwelcome complication of pregnancy. Theoretically it would seem to be due in most cases in which no obvious cause such as a blow or fall is present, to a failure of the normal mechanism which prevents the uterus from yielding to the physiological impulse to empty itself of the foreign bodies in its cavity the fetus, placenta and liquor. In the light of our present knowledge the most potent factor causing this inhibition is the corpus luteum hormones in the early weeks of pregnancy and later a similar functioning hormone produced by the placenta. For this reason we have used injections of corpus luteum extracts to supplement the amount the patient is producing in her own ovary or placenta to inhibit the action of the labor or expulsion mechanism. There are various indications for the use of corpus luteum extracts in this connection. Primarily it should be used in patients with a nonviable live fetus *in utero*. In such cases it may be necessary to inject rather larger doses when active uterine contractions are present and to

cut down the number and size of the doses after the acute symptoms have subsided, thus a satisfactory maintenance dose is determined. Three cubic centimeters of aqueous corpus luteum extract three to five times a day at first, gradually decreasing to one 3 cubic centimeter ampul every other day or twice a week, depending on the activity of the uterus. The material should be used prophylactically when operations on the uterus and adnexa become necessary during pregnancy, such as myomectomy, twisted ovarian cyst, incarcerated retroflexed gravid uterus, when necessity arises for a pregnant woman to take a long journey either by automobile, airplane, railroad or boat. For this purpose we usually advise 3 cubic centimeter ampuls, one twice a week and more often if necessary. If a patient has a psychic shock, such as bad news, extreme anger or fright, the administration of a few doses of the extract prophylactically is both logical and useful even before the symptoms of uterine contractions appear. In the same way it may be used prophylactically when intercurrent infections such as contagious diseases or pycitis of pregnancy threaten to bring on uterine contractions because of the associated pyrexia. The injections may be used to combat the development of premature labor under these conditions or to prevent the onset of labor at or near term. The latter is much less likely to be successful than the former, and in either case it has been our experience that once real labor pains have started corpus luteum extract injections to stop them are useless. The danger of puerperal infection from uterine contamination under these circumstances is obvious.

fundus of the uterus first described by Braxton Hicks, which gradually become stronger as term is approached. Unfortunately, the separation may be sufficient to give an alarming hemorrhage as early as the 26th to the 28th week. Under such circumstances even if the initial hemorrhage subsides without serious danger to the mother the decision to postpone delivery until viability of the baby requires considerable courage on the part of the patient and physician. Since no one can say when further separation may result from the continuance of the uterine contractions nor whether or not the resultant hemorrhage may prove fatal to both mother and baby, it becomes obvious therefore that a substance which can be relied upon to inhibit uterine contractions in a physiological manner should automatically stop the formation of the lower uterine segment, and thus stop placental separation and hemorrhage. Acting on this assumption, we have treated 18 cases of placenta previa in which it seemed desirable to permit gestation to continue for a few weeks longer to give the baby a better chance of survival. The results have been most gratifying. No serious secondary hemorrhage occurred during such treatment. Under these circumstances when the baby has attained sufficient intrauterine development, usually 32 weeks or more, we delivered it by cesarean section, or otherwise, depending on the conditions present in each case at the time it became necessary or advisable to terminate the pregnancy. This method has the advantage over all other procedures of eliminating vaginal manipulations of all kinds until time for delivery, thus decreasing the danger of puerperal infection after delivery.

#### PLACENTA PREVIA

When the ovum is implanted and the placenta develops in the lower portion of the uterine cavity, it must inevitably detach in part with the formation of the lower uterine segment. The amount and suddenness of the detachment and the stage of gestation at the time the separation occurs determines in large measure the amount of bleeding and the danger to the life of mother and baby. The cause of the formation of the lower uterine segment is the painless contractions of the

#### PARTIAL PREMATURE DETACHMENT OF THE PLACENTA

In a somewhat similar manner the injections of this hormone are used to quiet uterine contractions when the diagnosis of partial premature detachment of the placenta was made before the fetus has reached the age of viability. Under these circumstances the irritation produced by the presence of blood clots between the placenta and membranes at the site of placental detachment stimulate stronger Braxton-Hicks contractions which in turn

may cause more placental separation. The logical remedy therefore would seem to be to inhibit these contractions until the fetus has reached viability and then to rescue it before further separation causes death by doing a cesarean section. This plan has been followed in 46 cases, with no maternal mortality and a fetal mortality of 9 per cent. Since the maternal mortality has been quoted from 15 to 30 per cent by various writers, and the fetal mortality placed at from 50 to 100 per cent it is obvious that this management is a distinct advance in the treatment of this condition. It may be objected that in these cases we are dealing with a minor degree of partial separation, and not the dangerous complete separation, and that therefore our results are not comparable with other reported series. The answer to this argument is that almost all complete separations go through the stage of partial separation, and that by prompt management of the incomplete variety we obviate the more dangerous complete variety. Not a single case of this series went on to the formation of a Couvelaire uterus. It would appear then that when this serious pathological condition occurs in cases untreated by these injections, the failure to inhibit uterine contractions contributed to the uteroplacental apoplexy. When the hemorrhage was completely controlled by the injections, and when the evidence pointed to the fact that only a small amount of separation had occurred at the time the patient came under treatment she was allowed to proceed with the pregnancy and to deliver spontaneously. If no further hemorrhage occurred. However the fetal heart tones were carefully and frequently observed for evidence of signs of embarrassment of the fetal circulation during the later weeks of pregnancy and during labor.

#### EVALUATION OF STUDY

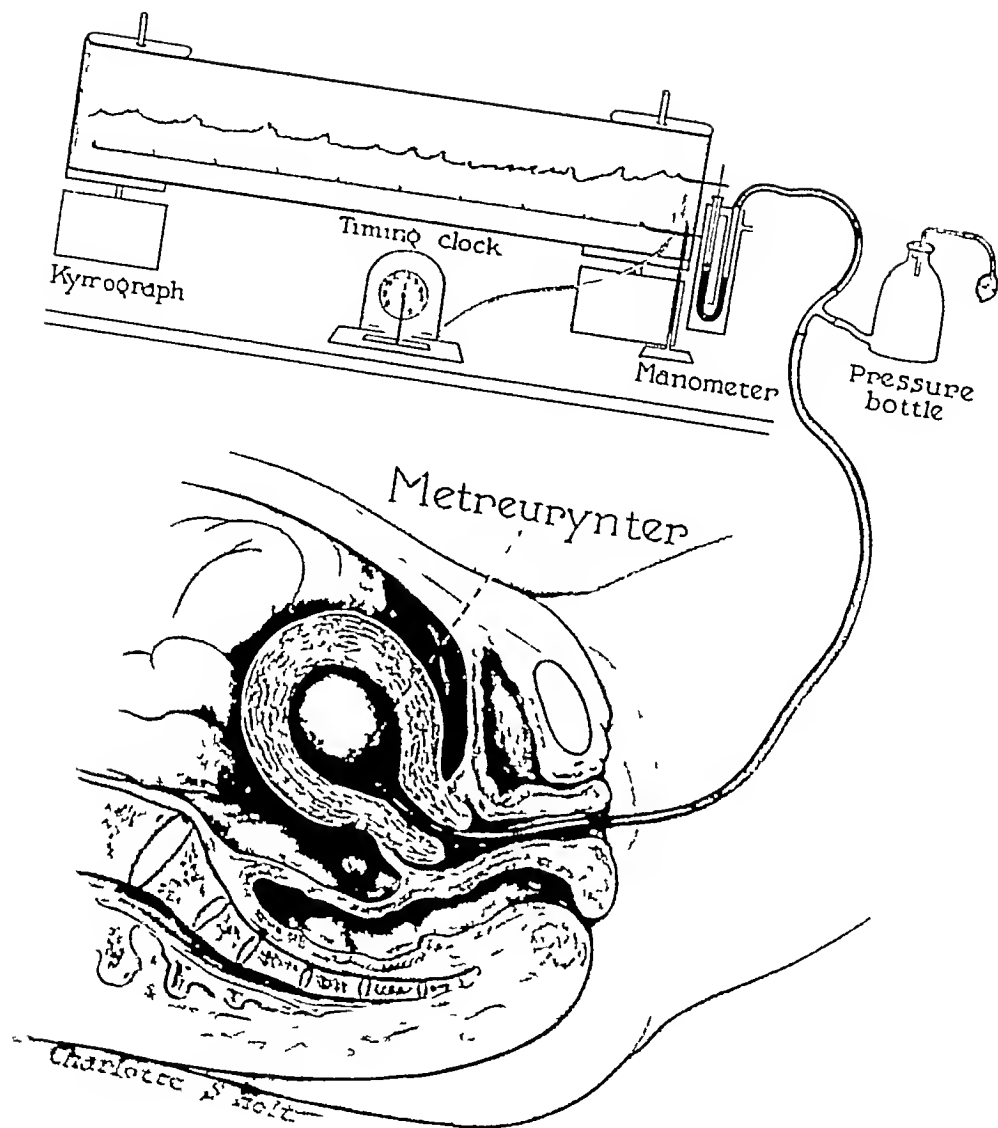
Since the early publication of favorable results in the treatment of threatened and habitual abortion by the use of corpus luteum extracts by Krohn, Falls, and Lackner there has been considerable controversy regarding the efficacy of these injections. We have received reports indicating that the results obtained by following our line of treatment

were excellent from certain men, and indifferent from others. Three factors at least may contribute to the production of these results.

It must be recognized that not all preparations contain the same amount of contraction inhibiting hormone or hormones, and not all patients have a living fetus *in utero* at the time they come to the physician for advice. The physicians using the corpus luteum extract often are not sure in their own mind of the efficacy of the material and therefore give it in a haphazard manner or fail to impress the patient with the necessity of co-operating by carrying out orders strictly until all danger of delivering a nonviable premature fetus is past. Suffice it to say that more and more clinicians are convincing themselves of the clinical value by using the hormones instead of condemning their use on theoretical grounds.

The dosage necessary in a given case may be very difficult or impossible to estimate accurately. This is so because each woman is manufacturing her own hormones in the placenta, and the injections supplement this natural supply. We go on the general broad assumption that it is better to give too much rather than not enough. As soon as symptoms of abortion arise, therefore, large doses frequently employed intramuscularly or even intravenously are used until the symptoms are brought under control or until it is evident that the case cannot be controlled by the injections of corpus luteum extract. If the symptoms are controlled for 24 hours, the dose is gradually decreased and an attempt is made to determine a maintenance dose. This is continued until the viability of the baby is assured, about the 34th week.

The use of corpus luteum extracts in placenta previa and premature detachment of the placenta has raised considerable adverse criticism from some obstetricians. This according to their own statements is not based on the use of the hormone in this type of case, but on theoretical grounds entirely. Their objection is that one must not temporize with a dangerous condition like placenta previa since a fatal hemorrhage may follow any form of expectant treatment. We wish to emphasize that we do not advocate the use of hormone in all cases of this kind or for an indefinite period of time.

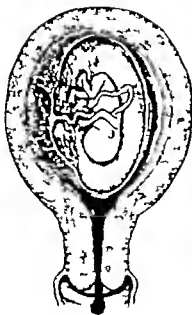


*Fig 5 Method of demonstration (Moir)*

The metreurynter in 7 day puerperal uterus records contractions in response to stimulation by posterior pituitary extract producing kymographic tracings. Contractions are inhibited by subsequent injections of extracts of corpus luteum

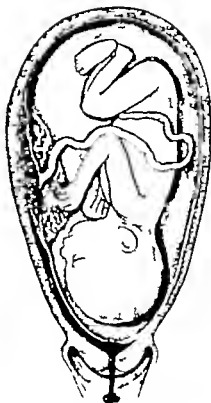
*Clinical and Experimental Observations on the Use of Corpus Luteum Extracts in Obstetrics*  
 Frederick H. Falls, George H. Reed and S. J. Bensonsohn





*Fig 6 Threatened abortion  
(3 month fetus)*

Injections reduce uterine irritability and prevent response the stimulus producing abortion even after partial placental detachment.



*Fig 7 Inevitable abortion  
(3 month fetus)*

Prophylactic injections started as soon as pregnancy is determined prevent uterine contractions such produce placental separation and fetal expulsion.

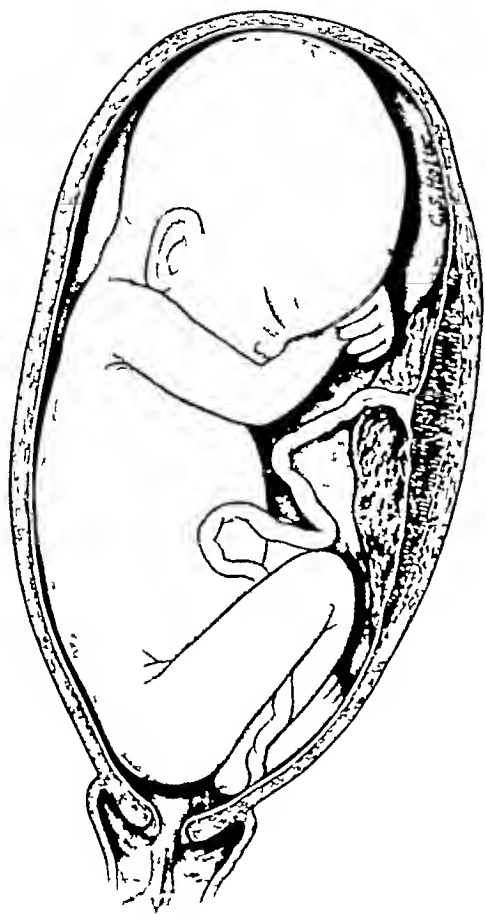


Fig 8 Premature rupture of membranes  
(7 month fetus)  
Usually results in expulsion of fetus within  
4 hours. Injections often delay the onset of  
labor by days or weeks. They are contra-  
indicated by evidence of infection.

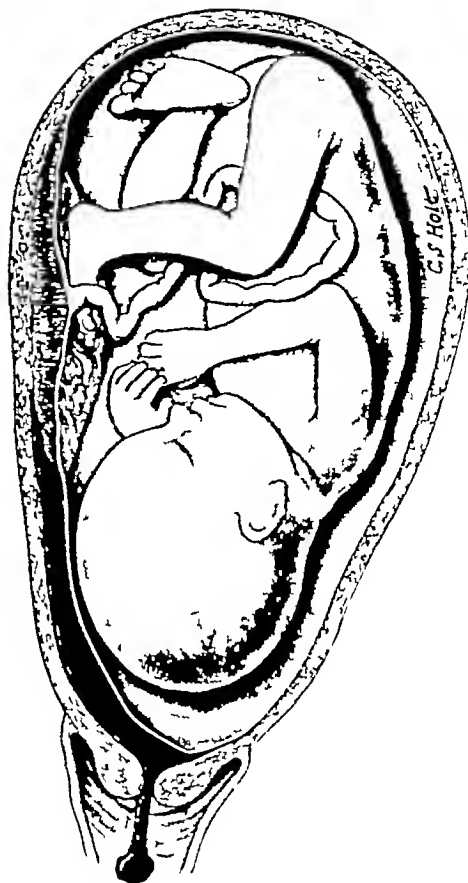


Fig 9 Premature detachment of placenta  
(6 month fetus)  
Results in irritating intrauterine clots stimu-  
lating uterine contractions and further de-  
tachment. Injections stop contractions per-  
mitting development of nonviable fetus or  
if viable, preparation for operation.

W.A. Bldg.



Fig. Premature end of labor  
(3 month fetus)

Weak pains of early premature labor are controlled by injections even after the partial dilatation of the cervix has taken place. After labor is well established, injections are useless.

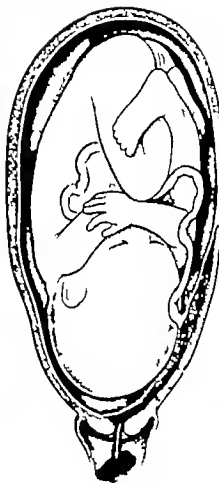


Fig. Placenta previa  
(7 month fetus)

Braxton-Hick contractions form lower uterine segment resulting in detachment and hemorrhage. Injections stop contractions and further separation, permitting fetus develop to full term.

any case. We wish further to state that, in the presence of severe hemorrhage, hormonal treatment should be disregarded in favor of active measures to stop hemorrhage thus safeguarding the mother even at the sacrifice of a baby's life. If, on the other hand, a moderate hemorrhage occurs in a given case when the baby is almost viable, and stops spontaneously, or after injections of corpus luteum hormone, we are not forced to use radical measures. Now if we admit that further bleeding depends largely on uterine contractions directly or indirectly, and if it can be shown that these contractions can be stopped by the use of corpus luteum extract injections, we would not feel morally free of blame if either the mother or baby died under any other method of treatment, and we had failed to use the hormone. We are further fortified in this position because we have not as yet experienced the serious results by the use of the hormone so freely predicted by the men who have admittedly no experience in its use.

Whether the baby is alive or dead is an important consideration in many cases before treatment is started. It is usually easy to diagnose the intrauterine fetal death by the characteristic signs and symptoms. However, in certain instances the diagnosis may be much in doubt when the physical findings are difficult to make out. In these cases the Friedman modification of the Aschheim-Zondek test may help to determine whether or not pregnancy is present. Corpus luteum extracts may then be used while the uterus is kept under observation to see if normal development occurs. We have found that, if the fetus is dead, corpus luteum injections will not prevent its expulsion in most cases.

Among the various objections to the use of corpus luteum extracts in the treatment of abortion is the observation by Payne and others that in a considerable number of abortions there is evidence of abnormality of the fetus, the placenta, or both. The possibility therefore of preserving *in utero* a fetus that might become a monster or be deficient in some respect must have due consideration. The objection is theoretical and not real in our experience. We have delivered only one monster or deformed fetus in 650 cases, which

would indicate that the occurrence in this case was in all probability accidental.

The use of the hormone when premature rupture of the membranes has occurred at or before the 32d week of gestation is both logical and desirable. Practically, it has been found to inhibit successfully the onset of labor in a large percentage of the cases. Under ordinary circumstances labor will start within 24 hours. We have found that the onset of labor pains can much more readily be prevented than stopped after they have started. Fever appearing a few hours after the membranes have ruptured is a contraindication to corpus luteum extract injections, since it usually means contamination of the amniotic sac from the vagina and often a certain degree of placentitis. The possibility of salvaging a living premature baby that would survive is naturally remote, and the sooner such a fetus is delivered the better for all concerned. We have had no case of serious puerperal sepsis or pelvic infection following the use of corpus luteum extracts in this type of case.

We have purposely avoided the use of sedatives and vitamin L preparations in treating these cases, not because we felt that the latter had no therapeutic value, but to prevent clouding the issue as to what was preventing the abortion. We wished to attribute the results obtained to one therapeutic agent only. In the light of reports concerning the favorable action of vitamin L therapy, especially on habitual abortion, it may well be that a combination of corpus luteum hormones and vitamin L therapy would be found to be more efficacious than either alone.

In no case was threatened abortion considered when patient simply spotted on a few occasions during pregnancy. In most instances the passage of clots or severe cramps gave evidence of active uterine contractions.

It is interesting and significant that the three independently conducted series here recorded provided almost identical results. Obviously, more investigation of the hormones of the corpus luteum is imperative to a better understanding of the results obtained by us and by other investigators. However, until such work has been completed we have shown that highly satisfactory results can be

obtained by the preparations at hand and at not too great expense not only in threatened and habitual abortion, but also in several other important obstetrical complications.

As a result of our observations of the frequency of abortion in pregnant women previously treated for sterility we used corpus luteum extract prophylactically in a series of private cases. The results seem to indicate that the hormone is of marked value in reducing the tendency to abortion in such cases. The hormone injections are made in the same manner as described for habitual abortion. In 45 cases 2 patients aborted. The abortion rate after the aqueous corpus luteum extract injections were used routinely was 5 per cent, whereas, previous to the use of the hormone 5 cases of this type miscarried in a series of 15.

It is difficult to determine the value of the corpus luteum injections in connection with many medical and surgical complications of pregnancy such as pyelitis, pneumonia, appendicitis, twisted ovarian cyst, and fibroids of the uterus.

The danger of spontaneous abortion in connection with these diseases and surgical conditions is well known and generally admitted. Our combined experience leads us to believe that the use of corpus luteum extract prophylactically helps to prevent abortion or premature labor in well over 75 per cent of cases.

It may be well at this time to mention some of the unfavorable factors in the treatment of abortion by these injections. In private practice it may be difficult to get the necessary co-operation of the patient, after the acute symptoms have subsided. It may be difficult for the patient to be hospitalized and the physician cannot always make the regular visits, sometimes three a day which are necessary in order to maintain a pregnancy in a uterus threatening to abort. The expense involved often caused us to lessen the number of injections which should be given to reduce the pain and spotting. We have found that a visiting nurse often could be relied upon to give the injections.

The Cook County Hospital patients were on the whole less intelligent than the two other groups. Also as a group they entered

the hospital at a later period of the abortion than other groups and therefore were not a favorable prospect from the standpoint of treatment.

The Research and Educational Hospital group were slightly more intelligent than the patients in Group II. They came under treatment slightly sooner in the course of the threatened abortion. However the follow-up on these cases was much more difficult since they came from more widely scattered communities and inadequate social service and follow-up personnel was not available. The chief reason for failures in all groups were nonco-operation and undertreatment.

Syphilis as a serious cause of abortion in this series was very uncommon. In the 11 cases showing positive serological findings only 3 gave evidence that syphilis was a contributing factor.

For the purpose of this investigation, sedatives were not given to these patients except in the private practice of one of us (Dr. Reak) because we wished to be able to say that the hormone only could be responsible for favorable results, and for the blame if they did not occur. However we see no objection to giving mild sedatives to reduce irritability of the patient, except that the number and severity of cramp-like pains may serve as an index as to the necessity of increasing the dosage of corpus luteum extract.

#### CONCLUSIONS

1. Corpus luteum extracts used in the series of 650 cases contain a substance which when injected intramuscularly or intravenously inhibit uterine contractions and thus help to prevent abortion.
2. The injections will not prevent abortion when the fetus is dead.
3. The injections are contraindicated in the presence of uterine infection or mole pregnancies.
4. The prolongation of gestation by means of these injections when the fetus is on the borderline of viability and premature delivery seems imminent is desirable and not unreasonably dangerous.
5. It has apparently proved efficacious in cases in which surgical emergencies necessitated

tated laparotomy in preventing the onset of labor and abortion

6 Patients with fibroid uteri and sterility cases who eventually become pregnant should be given injections prophylactically until the fetus has reached viability

7 No untoward results have been noted in those patients who received the aqueous preparations even when given in relatively large doses (15 c c) intravenously

8 The success of the treatment described depends upon the regular administration of

adequate dosage, and upon the continued co-operation of the patient under the close supervision of the physician

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# THE INTRAVENOUS USE OF AMINO ACIDS FOR NUTRITIONAL PURPOSES IN THE SURGICAL PATIENT

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THE value of a parenteral supply of protein to the patient who can not ingest, digest, or absorb food normally has long been appreciated. As early as 1902 attempts were made by Loewi to administer protein digests by mouth. Similar predigested meat products were given rectally by Abderhalden and intravenously by Henriques and Andersen.

In 1934, Rose pointed out the possibility and advantages of maintaining a patient in nitrogen balance by administering a mixture of all the essential amino acids. However the administration of such a mixture of pure isolated amino acids is prohibitively expensive, and in such a mixture the possibility exists that some essential amino acids may be lacking. In order to circumvent these difficulties, Van Slyke and later Cox and Mueller worked with mixtures of amino acids derived from an acid hydrolysis of casein. It was then learned that this process destroyed the tryptophane, one of the essential amino acids. However when the casein was hydrolyzed by slow enzymatic action, tryptophane was spared. This last preparation, when fed to rats orally maintained nitrogen balance and produced the same gain in weight as did unaltered casein (10).

In 1939, Elman and Weiner (9) administered intravenously an acid hydrolysate of casein to which tryptophane and cystine were added. They found that nitrogen equilibrium could be maintained in humans with this mixture as the only source of protein. The following year Elman (7) reported the successful intravenous administration of an enzymatic hydrolysate of casein to adults. Shohl, Butler Blackfan, and MacLachlan reported similar work with children.

We wish to describe our experiences with an enzymatic hydrolyzed amino acid prepara-

tion, and shall consider: (1) a method of preparation (2) intravenous dosage and toxic reactions (3) evidence of utilization by the body and (4) the effect on the regeneration of plasma proteins.

## PREPARATION

The enzymatic hydrolysate of casein, known as amigen, is supplied as a refined powder ready for use. It contains 12 per cent nitrogen, of which 26 per cent is polypeptide nitrogen, and the rest amino acid nitrogen. There is no unhydrolyzed protein. The ash content is 3.5 per cent and consists chiefly of sodium, chlorine, phosphorus, and sulphur (15).

The amigen is weighed out in 100 gram portions and each portion is dissolved in one liter of distilled water. The resulting 10 per cent solution is passed through a Berkefeld filter W and is diluted to a 5 per cent solution under sterile precautions. It is then sealed in a sterile container, steamed over a water bath for 30 minutes, and may be stored on ice or at room temperature.

There are a few simple precautions that deserve mention. If amigen powder is allowed to stand exposed to the air longer than a day it absorbs moisture and turns into a firm, clay-like material which is difficult to dissolve. The powder should be dissolved within a few hours after a sealed container is opened. Inasmuch as amigen solutions are excellent culture media, strict asepsis must be maintained in preparation and administration. A solution which has been properly prepared for use should be clear and subsequent clouding of the solution is a sign of contamination.

Glucose, thiamine chloride, nicotinic acid, ascorbic acid, and 0.8 per cent sulfanilamide solution may be added to amigen solution. However the addition of sodium sulfapyrazine and sodium sulfathiazole in 1 per cent solution produce precipitates that render the mixture unsatisfactory for intravenous use.

From the Surgical Service of Dr. Ralph Cole, and the Chemical Laboratory, The Mount Sinai Hospital, New York.

# INTRAVENOUS DOSAGE AND TOXIC REACTIONS

In calculating the dosage of amigen, one must remember that it is a food substitute, and therefore a number of factors should be taken into consideration, namely (a) protein requirement, (b) previous state of nutrition, (c) other sources of food, (d) fluid balance.

The daily basal protein requirement for an adult is roughly 1 gram of protein per kilogram. Unpublished observations (18) have shown that 0.7 to 0.8 grams of amigen per kilogram per day will maintain an active man in positive nitrogen balance. Larger quantities of amigen are required if there are additional protein needs. This is necessitated by febrile states, and the formation of body exudates such as ascites. It is also indicated following extensive operative procedures in which there is an excessive nitrogen loss in the urine. This is probably due to local tissue destruction at the operative site and increased general protein utilization following temperature elevations.

The previous state of nutrition must also be considered in determining dosage. For example, if a state of chronic inanition has existed due to pyloric stenosis, obstructive lesion of the esophagus, or extensive ulcerative colitis, it is not only necessary to supply immediate protein needs, but it is vital to build up again depleted reserves.

If food may be administered via a gastrostomy or jejunostomy, or if the patient is able to take nourishment by mouth during the convalescent period, there is no further need for intravenous amino acids.

The state of the fluid balance plays a major role in limiting dosage. The use of amigen has been limited to 2½ to 5 per cent solutions because of toxic reactions which shall be discussed subsequently. Consequently it requires 1000 or 2000 cubic centimeters of fluid to administer 50 grams of amigen, depending upon the concentration. A 5 per cent glucose solution is added to the solutions to increase their caloric value. Since a combined 5 per cent glucose and 5 per cent amigen solution contains 400 calories, the basal caloric requirements are supplied by approximately 3 liters. This is not an excessive fluid intake

unless the patient has hypoproteinemia, or cardiac or renal failure. If these conditions exist, with peripheral or pulmonary edema, the amount of amigen solution must be curtailed.

To summarize, it has been our practice to supply daily 50 to 100 grams of amigen in 2½ or 5 per cent solutions. To these are added sodium chloride, vitamins, and glucose in sufficient amounts to bring the caloric intake to 1200 to 2000 calories. The dosage is limited by fluid tolerance and certain toxic reactions.

Unfavorable reactions have been reported by others using intravenous amino acids. Shohl and associates found that in children, many developed febrile reactions and macular rashes. A small percentage of Elman's cases displayed chills and fever (7). Farr (11) describes the frequent occurrence of flushing, warm sensations, nausea and vomiting following the rapid administration of large quantities of amigen.

In this current series, amigen was given intravenously in doses of 50 to 100 grams to 75 patients. No manifestations such as urticaria, angioneurotic edema, or foreign protein febrile response have been observed.

In one group, 1000 cubic centimeters of a 5 per cent amigen solution was administered in 1½ hours. These patients frequently experienced flushing of the face, a feeling of warmth, and frontal headache. A few had retching and vomiting. None of these symptoms occurred when amigen was given slowly, i.e., 120 to 240 cubic centimeters per hour.

The one reaction that has caused concern is the development of phlebitis following the administration of hypertonic solutions. A 2½ per cent amigen solution is approximately isotonic (7), and is scarcely more irritating than normal saline. In fact, a 5 per cent amigen solution may be given continuously for 48 hours without causing phlebitis. Fortunately, no ill results were observed following an occasional infiltration of the perivenous tissues. The swelling which occurred disappeared completely without inflammatory reaction within 24 hours. However, if 5 to 10 per cent glucose is added so that the solution becomes markedly hypertonic, endophlebitis is liable to occur.



## SURGERY GYNECOLOGY AND OBSTETRICS

TABLE I.—AMINO ACID IN BLOOD AND URINE

Case No. Name Number Date	Diagnosis	Blood			Interval	Urine				
		Injection Cured Time A.M.	Amino acid nitrogen mgm.	Urea nitrogen mgm.		Volume (quantity) c.c.	Amino acid nitrogen gm. per liter	Amino acid nitrogen total excreted gm.	Total amino acids per liter gm.	Fe. ex- cretion total g. per day
J. P. 46417 2-26-42	Post-operative appendicitis	7:30	7.4	25	80-100 m.	300		.045	54.5	
		8:30		30	100-150 m.	300				
		9:00		25	100-150 m.	300	.17	.052	5.2	
		10:30	8	25	100-150 m.	300				
		11:30	8	30	100-150 m.	300	.13	.077	35	
R.G. 46424 2-26-42	Hernia	7:30		30	100-150 m.	300	.20	.06	17	
		8:30	8	30	100-150 m.	300				
		9:00		30	100-150 m.	300		.025	12.5	1
		10:30		25	100-150 m.	300				
		11:30			100-150 m.	300		.064		
J.W.C. 46449 2-27-42	Regional thrombosis	8:30	8		100-150 m.	300	.094	.045	8	2
		9:00	8		100-150 m.	300	.13	.099	8	2.5
		10:30		1.5						
		11:30	8	8						
		12:30								
W.H. 46453 2-27-42	Duodenal ulcer	8:30		1.5	100-150 m.	400	.06	.099	1	
		9:00	10.5	30	100-150 m.	300	.10	.065	1	1.5
		10:30	6		100-150 m.	300		.065	14	
		11:30								
		12:30								
L.K. 46454 2-27-42	Duodenal ulcer with chronic nephritis	8:30	6	30	100-150 m.	400	.17	.090	15	
		9:00	8		100-150 m.	300	.13	.095	29	
		10:30	8	25	100-150 m.	300	.06	.066	17	1
		11:30	6							
		12:30								
M.D. 46456 2-27-42	Severe acute hepatitis	8:30	8	15	100-150 m.	400		.065		1
		9:00	10	1.5	100-150 m.	300	.20	.075		1
		10:30	30	20	100-150 m.	300				
		11:30	8	30	100-150 m.	300	.06	.066	3.6	
		12:30	7	19						

This danger of phlebitis may be minimized by inserting the needle at the junction of two veins, and administering the solution at a rate of only 2 to 4 cubic centimeters per minute

The hypertonic solution may thereby be more rapidly diluted with venous blood and it becomes unnecessary to change the site of injection for at least 24 hours.

# EVIDENCE OF UTILIZATION BY THE BODY

Two facts strongly support the theory that this amino acid mixture is utilized by the body for nutrition (a) The amino acids are rapidly absorbed from the blood stream by the body tissues and are not lost in the urine (b) A positive nitrogen balance may be maintained with amigen as the sole source of nitrogen

*Absorption by the tissues* Van Slyke and Meyer injected dogs with large amounts of an acid hydrolysate of casein and found that after a half hour, only 5 per cent remained in the circulation and 11 per cent was excreted in the urine Elman (6) also reports similar results in dogs Farr and MacFadyen (12) gave amigen to nephrotic children and found that the urinary loss was insignificant Altshuler, Hensel, and Sahyun injected a 10 per cent solution of an acid hydrolysate of casein fortified with tryptophane and cystine into 8 normal persons They found about a 10 per cent loss in the urine

In order to study the absorption of amigen by the tissues and loss in the urine, a group of experiments was performed Fifteen patients were selected The diagnoses of this group are listed as follows hernia, 4, duodenal ulcer, postoperative appendicitis, sciatic syndrome, hepatitis (2 mild, 1 severe), myasthenia gravis, muscular dystrophy, regional ileitis, duodenal ulcer with chronic nephritis, chole- docholthiasis with jaundice

Fifty grams of amigen in 1 liter of solution was administered to each patient The time of injection was 1½ hours Blood samples were taken at half hour intervals for a 4 hour period and tested for amino acid nitrogen and urea nitrogen Urine collections were begun 8 hours prior to the injection period and were continued for several hours after The urine was tested for amino acid nitrogen and total nonprotein nitrogen

The amino acid nitrogen in the blood and urine was determined by the Folin colorimetric method, urea nitrogen by the Van Slyke aeration method, and the nonprotein nitrogen by the Nessler method (Table I) As examples, the results of the tests in 6 patients are charted The blood amino acids rose from fasting values of 5.8-7.4 milligrams per cent to a maximum of 10.4 milli-

grams per cent, and rapidly returned to normal The amount of amino acid excreted in the urine never exceeded 0.6 grams which is equivalent to 1.5 per cent of the amino acids injected The curves in all of the cases are very similar, with these two minor exceptions The blood urea rose 8 milligrams per cent in Case 5, a patient who was in mild uremia In the remainder, the blood urea showed only insignificant elevations The other exception was in Case 6, a patient suffering from a moderately severe hepatitis in whom amino acid fraction of the total urinary nitrogen was as high as 8.6 per cent as compared to a normal of 1 to 2 per cent We believe that these experiments warrant the conclusion that this preparation is rapidly absorbed from the blood stream by the body tissues and is not lost in the urine This was noted in a variety of diseased states

*Nitrogen balance* The maintenance of positive nitrogen during the administration of amigen is evidence that the body utilizes this hydrolyzed protein A number of authors have reported success in this regard in both laboratory animals and human subjects (4, 5, 7, 11, 15, 20, 24) Two cases, both in starvation, will be described briefly Both attained positive nitrogen balance by means of intravenous amigen and glucose

**CASE 1** W M No 472034 A white male was admitted April 19, 1941, to the service of Dr John Garlock with a history of inability to swallow solid food for 5 weeks and liquids for 2 weeks He had lost 35 pounds in weight Physical examination revealed only marked malnutrition X-ray and esophagoscopy demonstrated a carcinoma of the lower end of the esophagus He was prepared for operation with the intravenous administration of amigen Preoperative urinary nitrogen excretion promptly rose from starvation figures of an average of 4.3 grams per day, to normal levels, and positive nitrogen equilibrium was attained (Table II)

An intrathoracic esophagostomy was then performed and a squamous cell carcinoma of the esophagus and an infiltrating adenocarcinoma of the cardiac end of the stomach were resected The patient made a complete recovery After operation, there was a huge nitrogen loss in the urine which was only partially replaced by the amino acids administered

**CASE 2** V V, No 471335 A 48 year old laborer was in excellent health until 5 months prior to admission, at which time he noted difficulty in swallowing and talking He lost 30 pounds and was mark-

TABLE II.—CASE 1 W. M.

Date	Nitrogen Intake		Nitrogen Output	
	Amino acid intake—gms.	Amino acid—gms.	24 hour urine—g	Total 24 hour urine nitrogen—gms.
4-24			730	69
4-25			300	30
4-26			1300	4.45
4-27		300	300	60
4-28		100	750	105
4-29		20	750	2.5
4-30			1000	80 <sup>a</sup>
5-1			580	45
5-2			1000	4.1
5-3		1	600	14
5-4			1200	30
5-5	4	50	1600	10
5-6	4	50	1700	15
5-7	4	50	170	
5-8			150	20.25
5-9			2000	1.04

<sup>a</sup>Operations.

Nitrogen balance is achieved temporarily as the starved patient by intravenous amino acids at the preoperative period. The large post-operative nitrogen loss is partly replaced by the same therapy.

edly emaciated. H. was admitted to the service of Dr. L. Wechsler. On examination there was inability to swallow, labored breathing, diffuse wasting of musculature, especially the tongue. The diagnosis was amyotrophic lateral sclerosis. Stomach tube feedings were employed but were complicated by edema of the larynx and bronchopneumonia. Because of these difficulties, oral feedings were discontinued, and the patient was fed by the intravenous route, with 10 per cent glucose and 1/4 per cent amino acids. Vitamins were added. After weeks the patient began to run, spiking temperature and died of bronchopneumonia and respiratory paralysis (Table III).

#### THE EFFECT ON THE REGENERATION OF PLASMA PROTEINS

Theoretically one would expect that the administration of amino acids intravenously to patients with nutritional hypoproteinemia might supply the necessary basic factors for plasma protein regeneration. Whipple (17) has concluded from his experimental work that the tissue proteins were in "dynamic equilibrium" with those of the plasma.

Plasma protein is a part of a balanced system

TABLE III.—CASE 2 V. V.

Calories	Intravenous fluids—c	Carbohydrates—gms	Amino acid nitrogen—g	Total nitrogen—g
1000	1000	100	5	1
300	300	200		
15	1700	150		1.5
1000	4000	400		
300	300	300		
300	1300	300	0.0	
300	150	300	0.0	1.1
600	3500	300	0.0	10.1
Total			69	69.7

Nitrogen balance achieved during 25 day period by the intravenous administration of amino acids and glucose. Following the post-operative bronchopneumonia and further progression of the disease metabolic death.

of body proteins a steady state of ebb and flow exists between the plasma proteins and a portion of the cell and tissue body protein. It may be predicated, therefore, that if depleted tissue proteins are replenished by amino acids, an increase in plasma proteins would result. Clinical reports, however, have failed to show any startling rises in plasma protein following intravenous amino acid administration. Both Ravdin and Farr (11) have reported cases of hypoproteinemia which failed to respond to intravenous amino acid therapy. Two cases of hypoproteinemia are presented as examples, in which intravenous amino acid therapy was given.

CASE 3. A. B. Hospital No. 467788. A 37 year old farmer was admitted 3 years previously for pyloric stenosis, and posterior gastroenterostomy was performed. Nine months ago he began to have 5 watery stools a day and fecal smelling eructation. He lost 4 pounds in weight. On examination he was cachectic. A gastrocolic fistula was demonstrated by x-ray. A preliminary right side upper colostomy was performed. Following this procedure the patient did poorly. Large amounts of fluid were lost by colostomy and the patient took very little by mouth. The blood protein fell to 4.1 grams per cent. He was given 475 grams of antigen in space of 8 days, but the development of phlebitis prevented further treatment. The gastrocolic fistula was disconnected, and jejunostomy was established for feeding purposes. The patient made a complete recovery (Table IV).

CASE 4. H. K., Hospital No. 474685. A 39 year old housewife admitted to the hospital as private patient of Dr. S. S. Bernstein and Dr. J. G. Garlock, complaining of postprandial nausea and

TABLE IV

Date	Hematocrit	Plasma proteins gms /100 c.c.	Amino acids gm
3-25	35	4.2	
3-27		4.4	
3-28			50
3-29	40		50
3-30		5.0	50
3-31			50
4-1	36		50
4-2		4.6	100
4-3			50
4-5	46	4.3	75
4-8	39	4.4	
4-16		5.8	
		5.4	

During a period of 8 days patient received large amounts of amigen intravenously. oral feedings were limited. There was no elevation of plasma protein during the period of amigen injection.  
\*The elevation of plasma proteins following the amino acid therapy was related to hemoconcentration.

TABLE V — CASE 4, H K

Date	Hemoglobin	Plasma proteins gms /100 c.c.	Amino acids gm.
7-7	88		
7-8			
7-9	88	4.2	50
7-10			50
7-11		4.2	50
7-12	90		50
7-13		4.7	50
7-14	90		50
7-15			50
7-16	90		50
7-17			50
7-18	85		50
7-19			50
7-21	80		50
7-23	75	5.5	
7-25	71		
7-28	71	4.8	
8-9	75		
9-2		5.1	
		5.1	

dogs, a readily available protein reserve was demonstrated which was sufficient to restore 40 to 60 per cent of the plasma proteins. When, however, both the reserve and plasma proteins have been depleted, and regeneration of these proteins occurs following the administration of exogenous protein, the reserve supply is replaced at least in part before the plasma proteins return to normal. A very similar process may have occurred in the 2 cases of hypoproteinemia here reported. The amigen administration may have produced some increase in the protein reserves that had been depleted by a long period of malnutrition. It is our opinion, nevertheless, that plasma or whole blood is unquestionably the ideal replacement in hypoproteinemia.

#### INDICATIONS FOR AMINO ACID ADMINISTRATION

What, then, are the indications for the intravenous administration of amino acids? As Farr (10) has recently pointed out, the prime indication is starvation of a patient in whom it is impractical to give protein by way of the intestinal tract. When starvation is

gastric fullness of 3 months' duration. X-ray examination revealed an extensive carcinoma of the stomach. A total gastrectomy, esophagojejunostomy, and jejunostomy were done. A jejunostomy for feeding was also performed. The postoperative course was satisfactory for 1 week. By the 9th postoperative day, however, her abdomen became distended and pulse rapid and thready. Blood proteins fell to 4.2 grams per cent. Beginning on the 12th postoperative day, 600 grams of amigen were given in 12 days. The blood protein levels are given in Table V. Unfortunately, hematocrit determinations were not done, but some information as to hydration can be gained from the hemoglobin determinations which are recorded. The patient also received transfusions and jejunostomy feedings in addition to amigen. Despite these measures the blood proteins remained low. Improvement was gradual and by the 9th week the patient left the hospital and was able to take a soft diet by mouth.

The above cases here briefly reported fail to show any significant elevation of the plasma proteins following intravenous amino acids. On the other hand no definite proof has been offered that amino acids given intravenously are valueless in cases of hypoproteinemia. These studies may be criticized from at least one standpoint, namely, that the amino acids were not given over a long enough period. This criticism is supported by studies of Madden and Whipple on the plasma protein regeneration following plasmapheresis in

accompanied by hypoproteinemia, plasma infusions should be given in addition to but not in place of amino acids. The latter are needed for immediate nutrition and for building of protein reserves to prevent further plasma protein loss.

There is another reason for giving amino acids intravenously, namely to prevent liver damage. Recently numerous investigations have demonstrated the value of a high protein diet in the protection of the liver (8, 13, 19, 23). Since amigen is an effective protein substitute it is logical to assume that it will function in the same way to protect the liver against damage. It might be advisable to use amino acids intravenously in treating hepatitis and prolonged obstructive jaundice.

#### SUMMARY AND CONCLUSIONS

The preparation, dosage and methods of intravenous administration of an enzymatic hydrolysate of casein are described. The toxic reactions are minimal and measures are suggested for their prevention. Evidence is presented that these amino acids are absorbed by the tissues and utilized in nutrition. The prime indication for administration is a starvation state, when a sufficient quantity of proteins cannot be made available through the gastrointestinal tract. This form of therapy is not an adequate substitute for plasma infusions in hypoproteinemia but should be used as a supplement to plasma.

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# THE PRESENT STATUS OF VAGINAL HYSTERECTOMY

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**R**EMOVAL of the uterus by the vaginal route must have been attempted by the earliest surgeons, that the surgeons of Alexandria performed the operation many years B C is quite probable. Among the Greek and Roman medical writings are allusions to the removal of the uterus through the vaginal route. However, the first case to be reported was by Berengaria (17) of Bologna in 1507 who performed a partial vaginal hysterectomy. During the next four hundred years methods for this operation were described by surgeons in several European countries. The first authentically reported vaginal hysterectomy in America was performed in 1829 by Warren who was professor of anatomy and surgery at Harvard. Between 1829 and 1877 a number of cases were reported, some highly successful and others less so, but no definite procedure was described or followed. It remained for Noeggerath of New York in 1877 to perform the first complete, definitely planned vaginal hysterectomy in America, and during the last quarter of the nineteenth century the operation gained popularity among a few American surgeons. Henrotin (17) has compiled a comprehensive historical review of the subject up to the beginning of the present century.

Individual methods have in recent years been described by Bissell, Pellanda, Werner, Gellhorn, Babcock, Heaney (14), Kennedy, Sampolinski, Chueco, and others. Older methods were in existence prior to the modifications introduced by these surgeons, each of whom has developed a more or less standard procedure, or has modified older and well known methods in an attempt to develop a superior technique. These are too numerous to describe separately, although most of the proposed procedures fall into two general groups (1) those in which hemisection of the uterus is performed, and (2) those in which the uterus is removed intact following circum-

cision of the cervix. In any given case the selection of operative maneuvers will depend upon the skill of the surgeon, the disease present, the condition of the patient, and the state of the field of operation.

It is not the purpose of this paper to condemn abdominal hysterectomy, but to emphasize the value and scope of the vaginal method. In this country vaginal hysterectomy has never become widely popular, although as Babcock points out, it has been enthusiastically praised by the small group which has employed it extensively. Greater familiarity with the transabdominal approach to the pelvis appears to be the principal reason for the comparative popularity among surgeons of abdominal hysterectomy. As a consequence a subtotal hysterectomy is often performed when a total hysterectomy is advisable or preferable.

Heaney (14) in 1934 demonstrated how low the mortality and morbidity of this operation can be, and expressed the hope that it might find a place in the armamentarium of every gynecologist. Emmert believes the procedure to be relatively safe and states that the uterus can be removed by the vaginal route in over 80 per cent of all hysterectomies. Green-Armytage finds that, although the operation is not popular among British surgeons, there can be no question that it is accompanied by less shock, more rapid convalescence, and a lower mortality than is hysterectomy by the abdominal route. Danforth is convinced that this very valuable mode of treatment is being neglected and states that "as our skill increases we are inclined to use it more and more." Heaney, in discussing Danforth's paper, said "I have done 831 vaginal hysterectomies in nonmalignant disease with three fatalities. Most of the operations were done for fibroids. Among these were 197 nul-liparas, some with intact hymens. In the last 369 it was necessary to morcellate 93 times." Tyrone and Miller followed 170 cases in which vaginal hysterectomy had been performed and

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found that 96.5 per cent showed complete relief of the symptoms of which these patients had previously complained. Babcock says that vaginal hysterectomy is the operation of choice if hysterectomy is required in the presence of hemorrhage and infection<sup>10</sup> and further says that the mortality in vaginal hysterectomy can be practically eliminated. Potter says, "as my experience increases I am convinced there is no other operation in gynecology that can compare with it for results," and quotes Kennedy to the effect that in his practice the operation had a mortality of less than one-half that of the removal of the non-suppurative appendix in America. Averett (1) points out that a skillfully executed vaginal hysterectomy is a decidedly less formidable procedure as determined by its demonstrable effect upon the patient than is the same operation performed with equal skill by the abdominal route.

Despite numerous reports of a mortality rate of less than 2 per cent for vaginal hysterectomy, Miller finds that, with the average surgeon, the mortality from abdominal hysterectomy is never under 5 or 6 per cent and may run 8 to 10 per cent. Nevertheless, surgeons deliberately choose the more hazardous approach, apparently because they are fascinated by abdominal surgery or because of a feeling that abdominal surgery confers greater distinction and substantially contributes to their recognition and reputation as abdominal surgeons.

During the past 30 years my associates and I have performed 564 vaginal hysterectomies in the first few years limiting the operation largely to cases of uterine prolapse and gradually extending its scope of usefulness (5). In the early years many vaginal hysterectomies were performed for carcinoma of the cervix and a few of these patients are still living, some after 25 years. X-ray and radium therapy is now the treatment of choice, and, except in a few instances, hysterectomy has been performed only after all evidence of malignancy was eliminated, or to cure a pyometra after the use of radium.

In the period between January 1, 1925 and January 1, 1942 a series of 567 vaginal hysterectomies was performed by myself with 3

deaths, or a mortality of 0.53 per cent. During the past 4 years I have performed 307 vaginal hysterectomies without a death. In Table I the figures for a 7 year period are compared with those of the leading proponents of the procedure as compiled from the literature.

TABLE I.—MORTALITY

Authors	Vaginal hysterectomy		Abdominal hysterectomy	
	No. cases	Mortality	No. cases	Mortality
Kennedy (19)	677	43		
Kennedy				
Green Armytage	200			
Thompson	266			
Tyano	37	64	137	
Babcock	200			
Richards <sup>10</sup>			77	
Wicks				
Averett (1)	834			
Smith	26		61	
Ellis	267	32	89	61

<sup>10</sup>In the cases analyzed 25 surgeons performed the abdominal and 46 the vaginal hysterectomies.

#### ADVANTAGES OF VAGINAL HYSTERECTOMY

The outstanding advantages of this procedure include the following:

1. Mortality and postoperative morbidity are lower. Shock practically never occurs.
2. Usually not more than 40 minutes is required for the operation, often including repair surgery of the pelvic floor.
3. Peritoneal viscera are not traumatized.
4. Since it is for the most part an extra-peritoneal procedure, the danger of infection is decreased, and if infection is present, dependent drainage is provided.
5. Postoperative incisional hernia cannot develop and there is no painful operative scar. The former is an important consideration in obese patients.
6. The infected cervix is always removed without peritoneal contamination. This precludes the persistence of a chronic focus of infection or the development of a carcinoma at the site of cervical erosion or ulceration.
7. The operation can be performed in conjunction with perineorrhaphy, repair of cysto-

calc, treatment of obstetric injuries, and other surgery without greatly increasing the time of operation or materially altering the condition of the patient

8 The uterine adnexa may be removed if coincidental lesions are encountered

9 The appendix may often be removed vaginally in addition to other surgery being performed

10 Omental and intestinal adhesions to operative scars do not occur, and separation and infection of abdominal incisions are avoided

11 The operation is well borne by the patient even in the face of a tedious morcellation of a large tumor mass

12 As in abdominal hysterectomy, the field of operation may be extended in this procedure. If it is found impractical to continue the vaginal hysterectomy because of a former abdominal wall fixation operation or for any other technical reason, the operation may be completed by the abdominal route

13 There is very little danger of damaging the bladder, ureters, or rectum. In our entire series we have injured the bladder or ureters in only one case. There was an escape of urine for 10 days following operation which did not prolong the patient's convalescence although it was a cause for worry

14 The operation may be performed in elderly patients who are poor risks for abdominal surgery

15 Vaginal hysterectomy can be performed in the presence of such general or complicating diseases as diabetes, cardiac disease, pulmonary tuberculosis, hypertension or nephritis in any of which a laparotomy might be contraindicated, or in the very obese individual in whom laparotomy is hazardous

16 The operation may be performed in the presence of old but still active parametritis which has not responded to conservative therapy. Resorption of the chronic inflammatory infiltrate occurring after removal of the uterus

17 Circulatory accidents such as embolism and thrombosis are largely avoided (Potter)

18 Pulmonary complications are fewer because the operation can usually be performed with nitrous oxide oxygen anesthesia and the Trendelenburg position need not be employed

The choice of an anesthetic is of little importance. Although we choose nitrous oxide oxygen in most instances spinal, local or an intravenous anesthetic have at times been employed

19 The cosmetic advantage of producing no abdominal scar is worthy of consideration

#### INDICATIONS FOR VAGINAL HYSTERECTOMY

The following diseases can be successfully treated by vaginal hysterectomy

1 Benign neoplasm of the uterus. These tumors may be quite large and multiple, those extending above the umbilicus having been removed vaginally following morcellation

2 Prolapsed uterus. Vaginal hysterectomy was possibly first performed for complete desensus. Many of the present day writers, unacquainted with this field of surgery, consider prolapse the only indication for this procedure

3 Extensive laceration, erosion, ectropion, and leucoplacia of the cervix. This type of lesion is frequently precancerous and should be eradicated when a hysterectomy is performed

4 Functional bleeding, especially in the menopausal period, which does not respond to endocrine therapy (Ottinger, Heaney (16))

5 Chronic subinvolution of the uterus

6 Uterine polyps, especially those showing a tendency to recurrence or exhibiting early malignant changes (Ottinger)

7 Persistent uterine leucorrhoea (Heaney)

8 Stenosis of the cervix which has not responded to less radical treatment, such as that following radium therapy producing pyouterus

9 Chronic metritis (Green-Armistage)

10 Vaginal hysterectomy constitutes the most effective treatment for carcinoma of the corpus uteri. The uterus should be removed intact. Radium and x-ray therapy, while replacing surgery in carcinoma of the cervix, should be used only as an adjunct to surgery in carcinoma of the fundus. The use of radiation in younger women without proved malignant disease is less scientific and more radical than vaginal hysterectomy because of the destructive action of the rays on the ovaries



## CONTRAINDICATIONS FOR THIS OPERATION

Opinions as to contraindications for vaginal hysterectomy depend largely upon the experience of the surgeon with the procedure and consequently his confidence in and enthusiasm for the method. It has been stated that the removal of particularly large uterine tumors should not be attempted vaginally and that vaginal hysterectomy should not be performed in the presence of pelvic inflammation and in those cases in which pelvic surgery has been performed. However large fibroids can be removed vaginally and chronic pelvic infection is not actually an obstacle. Extensive pelvic adhesions do not constitute a contraindication and can be dealt with as safely by the vaginal as by the abdominal route. Strictly speaking there is no definite contraindication, although there are certainly instances in which the transabdominal approach is preferable, and the decision as to method must be based upon the wisdom of the surgeon. Or as stated before, there is no objection should the vaginal approach be found impractical, to complete the operation by the abdominal route.

## TECHNIQUES OF VAGINAL HYSTERECTOMY

All of the varied procedures in vaginal hysterectomy fall into one of two groups: those in which the uterus is hemisected, as first described by Doyen, and those in which the uterus is removed intact. The former procedure is especially valuable when adnexal disease is present or a large tumor has to be delivered, the hemisection facilitating secondary operative maneuvers upon the attached adnexa. This method has been popularized in recent years by Werner. Because of the relative absence of vessels crossing the midline of the uterus hemisection is followed by very little if any hemorrhage. The second type of operation in which circumsection of the cervix is followed by delivery of the intact uterus is the usual procedure.

Different methods of handling the broad ligament and contained structures during delivery of the uterus are in use such as the suture method and the clamp method (Price Kennedy). In the latter method the clamps are left *in situ* for a number of days instead of reconstructing the pelvic floor by means of

ligatures. Despite excellent results claimed for it by Kennedy we believe the clamp method increases the possibility of injury to the bladder and ureters and can hardly be considered the best surgical procedure. Except in cases of prolapse much of the work is done blindly by the clamp method, and there is no more reason for performing a hysterectomy blindly by the vaginal than by the abdominal route.

The use of a ligature carrier and the taking of small bites of tissue as the operation proceeds, precludes the use of forceps or any equipment which would narrow the field of operation, obstruct vision, or complicate the procedure. The importance of careful hemostasis cannot be overemphasized here, when the operative field is small and should be well visualized. Elimination of clamps and forceps and the taking of small bites of tissue makes good hemostasis possible and renders injury to the bladder and ureters almost impossible. When excessive oozing is encountered, the tendency is controlled by the intramuscular administration of 10 to 40 milligrams of rectified oxalic acid solution (6).

While the technique of vaginal hysterectomy is varied to suit the various lesions for which it is performed, a typical procedure may be described as follows. With a weighted speculum in the vagina and a retractor in the anterior fornix lifting the anterior vaginal wall and the attached bladder well out of the way the anterior lip of the cervix is grasped with a tenaculum. A circular incision through the vaginal mucosa is made at the periphery of the portio vaginalis of the cervix. Following circumsection of the cervix, the original incision is deepened, the vesicouterine ligament is cut, the vaginal mucosa is pushed up from the cervix, and the lower portions of the broad ligaments are encountered. The broad ligaments are then grasped in small bites with the ligature carrier ligated and severed. It will be found that this procedure can be carried on for some time before the cul-de-sac is entered. The detached portions of the ligaments are pushed up and away to expose new tissues for ligation. As the operation proceeds the peritoneal folds and the anterior leaf of the anterior cul-de-sac come into view. If the operative

field is kept reasonably free of blood, there should be no difficulty in recognizing the various anatomical structures. When the peritoneum is entered the peritoneal leaf is secured by long catgut on forceps, which is then moved out of the operative field and the bladder elevated with a retractor before dealing with the remainder of the broad ligaments. This not only aids in visibility but eliminates the possibility of trauma to the bladder and, to a lesser degree, the ureters. As the posterior cul-de-sac is opened the peritoneum is sutured to the mucosa of the posterior fornix and held by a long suture with forceps attached. This exposes the uterosacral ligaments, which are ligated, not *en masse*, but with rather small "bites." Ligation of these ligaments greatly increases the mobility of the uterus and enables it to be brought down so that the remainder of the broad ligaments and the round ligaments are easily secured by multiple ligatures, and cut. Thus the uterus is delivered intact. A temporary gauze pack is usually placed in the posterior cul-de-sac to prevent injury to the intestines. This is especially important if the uterus is to be bisected or, in the case of large tumors, morcellated.

If the uterus is large and it is decided to bisect it, the cervix is first amputated and the uterus is split. If this still does not provide enough room for operation, the uterus can be morcellated, starting at the midline and removing enough tissue to reduce it to more workable size. Often large fibroids can be removed intact, but sometimes they, too, have to be morcellated. In this event both sides of the bisected uterus are held apart by means of Lahey or vulsellum forceps while the operation proceeds. If the fundus has been completely bisected, one-half may be pushed into the abdomen while the other half is being dealt with, or one-half may be removed and a single Kocher hemostat temporarily applied, or both halves may be removed, and two Kocher forceps left in place while the suturing for hemostasis proceeds. After the uterus has been freed, adnexal tissue may be removed if this is found necessary. Following salpingectomy, or further surgical work upon the ovaries or tubes, the ligaments are sutured together before the wound is closed it is well to examine

the appendix if it can be located in the right pelvis, an appendectomy, if decided upon, adds only a few more minutes to the operative time.

Any one of several closures can be made. The method of closure of the vaginal vault is also a matter of choice, three basic principles being kept in mind. The first is to maintain adequate support for the remaining pelvic organs and the vaginal vault by the proper approximation and suturing of the ligamentous structures of the pelvis during closure of the wound. The second is to peritonealize the raw surfaces, and the third is to maintain adequate drainage in all cases.

The pelvic floor is reconstructed by joining the round, broad, and uterosacral ligaments from either side with interrupted sutures. As the round ligaments are approximated, the anterior leaf of the anterior cul-de-sac is sutured to them in order to peritonealize the operative site completely. If the approximation sutures of the ligaments are allowed to remain long and are brought out as the vaginal mucosa is closed longitudinally by interrupted sutures, these are tied to the mucosal sutures. The mucosa will thus be tightly bound to the ligaments, thereby eliminating dead spaces and further oozing.

In the case of pelvic prolapse, the removal of the uterus is but a small part of the operation, and plastic procedures for the correction of cystocele, rectocele, or lacerated perineum must be completed. Gauze or a rubber or glass drainage tube should always be inserted. As a further precaution against bladder compression and as an aid to the comfort of the patient, a Foley catheter is placed in the bladder and allowed to remain for 3 to 5 days, at which time the pack is removed. If infection is present, sulfanilamide is packed into the operative wound before it is closed.

The preceding discussion of technique has obviously been quite general and emphasizes the pliability of this operative procedure and the fact that there should be no standard technique for vaginal hysterectomy. The technique should vary in the various situations for which it is indicated. The important point to emphasize is the grasping and ligating of the various structures as the operation proceeds, with care.

not to include too large a piece of tissue in each bite because of the danger of the ligature slipping.

#### OBSERVATIONS

While we advocate vaginal hysterectomy as the preferred method for removal of the uterus in the majority of cases, it must be realized that this is a major surgical procedure and its success, as well as that of other major surgery, depends upon the training and experience of the surgeon.

It is an operation for experienced surgeons and should logically be most properly and advantageously employed by one well trained in gynecological surgery. However, as in other surgical specialties, the general surgeon, as the result of special interest and experience, may become equally proficient. The younger surgeon would do well to select "easy" cases at first, extending the use of the operation as experience is acquired.

Quite naturally all treatment methods have enthusiastic adherents, which accounts for the fact that among those qualified to express an opinion, Potter advises the vaginal method in only 30 per cent of operations for the removal of the uterus, whereas Emmert believes that 80 per cent of hysterectomies can be performed vaginally. We believe that Emmert's estimate is a conservative one and are now performing nearly 90 per cent of hysterectomies by the vaginal route.

Greenhill is of the opinion that a hysterectomy constitutes excessive treatment for benign lesions of the cervix. With this view we are inclined to disagree, especially in the case of patients past the age of 40 years. The cervical portion of the uterus ordinarily measures between 3 and 6 centimeters in length. Infection of the cervix may extend almost the entire length of the cervical canal, usually farther than generally appreciated. Conization operations and amputation of the cervix are usually inadequate to eradicate the disease for which treatment is attempted. Coincident disease of the fundus and adnexa is too often present.

Its reproductive function once fulfilled the uterus is a useless organ and not infrequently a distinct liability to the patient. To the woman

over 40 years the loss of the uterus is a serious matter. Vaginal hysterectomy by the experienced surgeon is but slightly more difficult than amputation of the cervix, provides definite mechanical advantages and even produces more satisfactory results.

Vaginal hysterectomy provides for the routine removal of the cervix which is too often not removed in abdominal hysterectomies. Failure to perform a complete hysterectomy is regrettable because, if for no other reason, more than 5 per cent of carcinomas of the cervix develop in the retained cervical stump left behind in a subtotal hysterectomy. Averett<sup>1</sup> states that about 20 per cent of women who had subtotal hysterectomies performed, who never have been pregnant, develop cervical stump cancer.

#### CONCLUSIONS

1. It is believed that vaginal hysterectomy offers obvious advantages which are generally unrecognized.
2. The available procedures are such that they can be modified to meet practically any situation arising in the pelvis.
3. The operation carries a lower morbidity and mortality than does abdominal hysterectomy and can be performed in the presence of serious systemic complications.
4. There is no single standard technique for vaginal hysterectomy. We prefer the technique of grasping and tying small bites of tissue as the operation proceeds, eliminating forceps as far as possible, and believe it is the most practical technique in nearly all cases.
5. Postoperative complications of vaginal hysterectomy are rare and if they occur are of short duration.
6. Because of its several advantages the operation should be mastered and used by all surgeons doing pelvic surgery.
7. The conclusions drawn are based upon experience in performing over 1,500 hysterectomies by the vaginal route.

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# THE PROBLEM OF THE TREATMENT OF SECONDARY PEPTIC ULCER

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GASTROJEJUNAL ulceration remains a serious problem despite a trend to reserve operation on primary ulcers for those cases with bleeding perforation, or obstruction. This is attested by the reported incidence of gastrojejunal ulcer ranging from 1.7 to 2.4 per cent following gastroenterostomy and from 0.4 to 10 per cent following gastric resection (10). It was in the hope of clarifying the problem of treatment of secondary ulceration that the present study based on 81 cases followed at the New York Hospital was undertaken.

A review of the literature dealing with secondary ulcer reveals that, although much has been written on the subject, there is very little uniformity in either the substance of the reports or the manner of presentation. This is particularly unfortunate since the number of patients operated upon for secondary ulceration in any one clinic is not large enough to be of statistical value. For this reason it is suggested that reports dealing with the treatment of secondary ulcer be more or less standardized, and the following outline is submitted with this aim in mind (Table I).

## ETIOLOGY

Rather than review all the factors that have been said to be of importance in etiology we shall summarize the conditions under which secondary ulcer is likely to develop.

First these patients may be considered to be of a constitutional type—persons with so called ulcer diathesis—who under certain circumstances are predisposed to develop ulcer. The physiological make up of these people direct psychic stimuli to the upper gastrointestinal tract, so that in the presence of other factors, ulcer may develop.

Second the constant finding of considerable

acid in the presence of gastrojejunal ulcer indicates that a relatively high acidity is important in the development, or in the persistence of, an ulcer. In this group of patients, all who were carefully studied had considerable amounts of acid (60 degrees or more of free hydrochloric acid with adequate volume). This must not be interpreted as conflicting with the well established facts that many people without ulcer have high acidity and also that many patients who are asymptomatic after gastroenterostomy likewise have high postoperative gastric acidity.

Third, and by no means least in importance, is the fact that there are exaggerated psychic stimuli which, in the presence of the preceding factors, play an important rôle in the development of ulcer. These psychic stimuli produce not only a more constant and greater amount of gastric secretion and abnormal motility but also a change in the vascularity of the stomach and duodenum—an ideal setting for ulcer formation.

Finally a host of factors—poor operative technique, nonabsorbent sutures in the line of anastomosis, size and location of the stomach, irregular habits of living, overindulgence in alcohol and tobacco, faulty diet, etc.—have been considered as the cause of recurrent ulcer, but it is probably only in exceptional cases that one of these alone can be held primarily responsible.

These factors are emphasized because of their practical application in treatment. Since these patients have already proved their susceptibility to ulcer development, their prognosis should be guarded, no matter what form of therapy is instituted. Likewise since all of the patients have considerable acid, surgical therapy should be directed toward reducing the acidity of the stomach. Finally since 90 per cent were poorly adjusted to their environment, adequate treatment, whether conserva-

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TABLE I—OPERATIVE PROCEDURES

A Operations for secondary ulcer	Total no operations	Operative mortality	Follow up results			Number followed
			Good	Poor	Died	
1 Local procedures						
Closure of perforated marginal ulcer after gastroenterostomy	1	0		1		1
after resection	1	0		1		1
Excision of marginal ulcer after gastroenterostomy	3	0		3		3
after resection	1	0		1		1
Ligation of bleeding point after gastroenterostomy	1	1				1
after resection						
2 Pylorotomy after gastroenterostomy	3	0	2	1		3
3 Dismantling after gastroenterostomy for uncomplicated marginal ulcer	11	0	2	0		11
for perforated marginal ulcer	1	1				1
with local procedure on duodenum	3	0	1	2		3
4 Gastroenterostomy after closure of perforated ulcer	7	0	2	5		7
after dismantling	3	0		3		3
after pyloroplasty	2	0	1	1		2
5 Gastric resection after closure of perforated ulcer	7	0	5	2		7
after pyloroplasty	1	0	1			1
after dismantling	4	0	4			4
after gastroenterostomy	10	1	5	2		10
after resection	4	1	2	1		4
6 Miscellaneous						
Exploratory laparotomy	6	0	0	6		6
Excision of gastric ulcer after dismantling	1	0	0	1		1
Resection of Roux in Y after dismantling	1	0	0	1		1
B Operations for gastrocolic fistula						
1 Excision of fistulous tract after gastroenterostomy	1	0	0	1		1
after resection						
2 Dismantling	7	2	1	2	2	7
3 Resection after dismantling of gastrocolic fistula	2	1	1			2
after posterior gastroenterostomy	1	0	1	0		1
after resection						
4 Preliminary cecostomy followed by one of above						

NOTE  
At first glance this outline may seem much too complicated but even this detailed outline fails to cover all possibilities

tive or operative, must include a proper mental adjustment of the patient. However, in emphasizing these factors it is not meant that sound surgery is to be forced into the background but rather that these factors should be constantly borne in mind in planning operative therapy.

#### TREATMENT

Treatment of these ulcers may either be conservative or operative, except for those complicated by free perforation or gastrocolic fistula, both of which demand operation. Perforation into the free peritoneal cavity while rare, demands immediate operation, and the



TABLE III —LOCAL PROCEDURES—EXCISION OF ULCER, ENLARGEMENT OR REVISION OF STOMA

Author	No cases	Deaths	Results		
			No followed	Good	Poor
Alessandri	16	2			
Benedict	5	1	3	0	3
Starlinger	2	1	1	0	1
Walter and Claggett	4	1	3	1	2
Wright	64	4	41	9	32
Zukschwerdt and Eck	4	1			
New York Hospital	3	0	3	0	3
Total	98	10	51	11	40
Per cent		10		22	78

TABLE IV —DISMANTLING OF GASTROENTEROSTOMY

Author	No cases	Deaths	Results		
			No followed	Good	Poor
Alessandri	5	0	5	0	5
Benedict	6	1	5	1	4
von Haberer	4	0	2	2	0
Walter and Claggett	93	9	70	18	52
Wright	106	11	61	23	38
New York Hospital	14	0	14	3	11
Total	228	21	157	47	110
Per cent		10		30	70

therefore, believe that in an elective secondary operation for repeated bleeding, the operation of choice is dismantling and gastric resection of the Pólya type, rather than a simple pylorotomy

#### UNCOMPLICATED MARGINAL ULCER

The present treatment of uncomplicated secondary ulcer is, in general, far from satisfactory. Conservative therapy is held by most surgeons to be unsuccessful chiefly because of the high incidence of such complications as hemorrhage, perforation and gastrocolic fistula, some (16) have even concluded that every patient with a proved marginal ulcer should be subjected to operation. This policy, however, is probably too extreme, for undoubtedly a few secondary ulcers will heal satisfactorily under conservative therapy. Hurst, for example, reports that in a group of 25 patients such therapy cured 50 per cent, a much better result than was obtained in the patients in our group treated in this manner. In our group of 51 patients the results of conservative treatment were good in 11, or 21 per cent, poor in 35, or 69 per cent, and 5 patients, 10 per cent, died. Of the 35 poor results, 23 patients were subsequently operated upon for persistent symptoms. Benedict, and Lahey and Swinton in smaller series of cases, report results similar to those of Hurst.

To be successful, however, medical therapy should include not only an initial period of rest in bed, a restricted diet, and abstinence

from tobacco and alcohol, but also, and most important, a readjustment of mental attitude and adequate accommodation of the patient to his environment. The importance of the latter cannot be overemphasized, and it is interesting to find that, among the patients treated conservatively in our series, 9 of the 11 who responded satisfactorily were able in some way to make satisfactory mental adjustments. On the other hand, 29 of the 35 patients who failed to respond, also failed to adjust themselves satisfactorily. These figures accentuate the necessity for adequate psychiatric instruction as a major constituent of adequate conservative therapy. In general, a reasonable conclusion from the present evidence would seem to be that, if a really complete regimen of medical therapy is available, it should be given a trial but, if within a short time the ulcer has not healed, operation should be advised.

Satisfactory operative treatment up to the present time has been better achieved when gastric resection was done. This is particularly true in the treatment of marginal ulcer following gastroenterostomy. Local procedures, such as excision of the ulcer and enlargement or revision of the stoma, usually prove unsatisfactory and only delay the indications for more radical operation (Table III). One operation that has been widely used is a dismantling of the gastroenterostomy and restoration of the normal continuity of the gastrointestinal tract. This procedure has been found to be unsatisfactory, for, although



TABLE V—GASTRIC RESECTION FOR MARGINAL ULCER AFTER GASTROENTEROSTOMY

Author	No. Cases	Deaths	Results		
			K. fed lowered	Good	Poor
Almquist	12	6		20	
Konradt	6				
Furstenberg	125		96	88	8
Reisinger	27	6			6
Walsh and Clagett	42		45	22	
Wright	166	29	105	82	23
Zischewski and Eich	45	6			
New York Hospital	14		14	11	
Total	304	49	240	107	36
Per cent		16	79	35	12

the marginal ulcer is cured, the conditions which led to the formation of the primary ulcer have not been altered and these result in a 65 per cent recurrence of the original ulcer (Table IV). In an effort to avoid this, dismantling has been supplemented by some type of plastic procedure at the site of the original ulcer. Unfortunately these results also have been disappointing.

Because of the inadequacy of the less radical procedures, gastric resection has long been used, although not uniformly accepted as the operation of choice in the treatment of secondary ulceration, and the results obtained are uniformly better than those following any other surgical procedure (Table V). The largest series are reported by German authors (58) who state that 90 per cent of the patients had good results. Finsterer makes an important distinction between the operative mortality rates of resection following different original procedures and reports a mortality rate for resection of 81 per cent after a previous gastroenterostomy in contrast to one of 23 per cent following a previous resection.

The problem of secondary ulcer after a resection is a much more serious one since surgical therapy is limited to either a more extensive resection or an excision of the ulcer with revision of the stoma. Because the latter generally fails to prevent another recurrence, resection is strongly advised if circumstances permit but the exceedingly high mortality of

30 to 25 per cent in secondary resection should be borne in mind while therapy is being planned. Since recurrences do take place and the mortality is not low resection should not be regarded as infallible or be undertaken lightly and for these patients in particular conservative therapy should be given a fair trial.

The problem of the recurrence of a primary ulcer either after suture of a perforation or pyloroplasty or excision, is a relatively simple one. It is generally agreed that, if surgery is to be done, resection is the procedure of choice since less radical methods result in such a high percentage of failures.

Finally, whatever the operation that is undertaken it should be planned so that it can be terminated at any time. For instance, if a gastric resection has been decided upon, the gastroenterostomy should first be dismantled and then if the condition of the patient permits, the resection can be completed. In this manner the operative mortality can be kept at a minimum.

#### CASE STUDIES

Material for this investigation was assembled from 81 patients, 28 of whom after their original operation were treated conservatively and 53 of whom were subjected to secondary operative treatment. In this latter group of 53 patients there were 135 operations (53 primary and 82 secondary) for ulcer or its complications—an average of 2.5 operations per patient (Table VI). Every patient originally had a gastric or duodenal ulcer except one who was found to have both a gastric ulcer and a leiomyoma of the stomach. Although all the patients had their reconstruction operations in this hospital 35 had their original operative procedures elsewhere. In every case there has been a careful follow-up study so that each patient has been seen at regular intervals of not more than 1 year. Thus, in the computation of final results our conclusions are derived from several examinations, in addition to which x-ray studies were usually available. Since the results are based primarily upon subjective findings, they have been classified as either good or poor rather than as recurrent or cured. On the whole we



TABLE VI.—CASE REPORTS\*—Continued

Name Age in years	Duration of symptoms	Sex	Procedure	Date	Lesion	Result
B 40	10 yrs		PGE	1934	DU	Per
	10 mos		Resection	1939	MU	Per
S 41	3 yrs		PGE, excision of GU and tumor biopsy	1934	GU and biopsy tumor	Per
	day		Exploratory laparotomy. Gastrostomy	1939	GU	Not q.d.
B 34	14 yrs		PGE	1943	DU	Per
	37		Dismantling	1946	MU	Per
	41 1/2		Gastric resection, Billroth II	1947	DC	Good
	37		PGE	1946	DU	Per
C 34	3 yrs		Dismantling	1934	MU	Per
	12		Pyloric excision and anterior G.E.	1937	DC	Per
	3 yrs		Gastric resection	1940	MU	Good
W	3 yrs		Fixation of perforated DU and PGE	1934	Perforated DU	Per
			Fixation of perforated MU. Dismantling	1941	Perforated MU	Not q.d.
M, 37	6 yrs		PGE	1945	DU	Per
	37 1/2		Excision of PGE, anastomosis	1945	Stomach	Good
S 30	37		PGE	1940	GU	Per
	10 mo		Dismantling	1943	MU	Per
	37 1/2		Excision of GU	1943	GU	Per
B 34	18 yrs		Subtotal gastrectomy	1931	DU	Per
	37		Pyloric resection	1938	MU	Good
M 34	6 yrs.		PGE	1938	DU	Per
	10 mo		Pyloric resection	1940	MU	Good
O, 40	days		Fixation of perforated ulcer and PGE	1941	Perforated DU	Per
	3 mo.		Dismantling	1943	MU	Good
B 34	37 1/2		Before perforated ulcer	1946	Perforated DU	Per
	41 1/2		PGE	1944	DU	Per
	6 yrs		Pylorotomy	1940	DU and MU	Per
	10 mo		Gastric excision	1940	MU	Good
B 33	6 mo.		PGE and appendectomy	1934	DU	Per
	37 1/2		Dismantling gastroenterostomy. Pyloric pyloroplasty	1946	GCF	Not q.d.
B 42	37 1/2		PGE	1933	DU	Per
	15 1/2 yrs		Dismantling GCF	1937	GCF	Good
B 36	37 1/2		PGE	1937	DU	Per
	37		Dismantling GCF	1938	GCF	Per
J 36	37 1/2		Fixation of perforated ulcer and PGE	1930	Perforated DU	Per
	4 yrs		Laparotomy	1934	No ulcer	Per
	37 1/2		Dismantling GCF	1937	GCF	Per
	10 mo		Pyloric resection	1940	DU	Not q.d.
O, 33	14 yrs		PGE	1939	DU	Per
	10 mo		Dismantling GCF	1943	GCF	Per
	3 yrs		PGE	1939	DU	Per
	3 yrs		Dismantling GCF	1940	GCF	Per
	37		Billroth II	1937	DC	Good
	7 yrs		PGE	1933	DU	Per
W 30	10 mo		Dismantling	1946	MU	Per
	37 1/2		PGE	1939	DU	Per
	4 mo		Dismantling and resection	1947	GU	Good

TABLE VI—CASE REPORTS\*—Concluded

Name Age in years	Duration of symptoms	No	Procedure	Date	Lesion	Result
I 43	6 yrs	1	PGE	1927	DU	Poor
	8 mos	2	Excision of GC fistulous tract	1934	GCF	Poor
	10 mos	3	Dismantling GCF	1936	GCF	Died (p o)
L 32	1 yr	1	Perforated ulcer plication	1932	Perforating GU	Poor
	3 wks	2	PGE (2 mos after)	1932	GU	Poor
	5 yrs	3	Dismantling and pyloroplasty	1937	MU	Good
Z 37	20 yrs	1	Perforated ulcer plication	1935	Perforating DU	Poor
	4 mos	2	PGE	1936	DU	Poor
S 28	4 yrs	1	Perforated ulcer plication	1930	Perforating DU	Poor
	1 1/2 yrs	2	Perforated ulcer plication	1932	Perforating DU	Poor
	1 1/2 yrs	3	PGE	1934	DU	Good
M 41	1 day	1	Perforated ulcer plication	1938	Perforating DU	Poor
	2 wks	2	Gastric resection	1938	DU	Good
S 72	15 yrs	1	Excision of DU	1934	Perforating DU	Poor
	2 yrs	2	PGE	1937	DU	Poor
B 30	10 yrs	1	Perforated ulcer plication	1938	Perforating DU	Poor
	2 yrs	2	Gastric resection	1940	DU	Poor
H 46	15 yrs	1	Perforated ulcer plication	1935	Perforating DU	Poor
	3 yrs	2	Bilroth II	1940	DU	Good
M 54	6 mos	1	Perforated DU plication	1934	Perforating DU	Poor
		2	Pylva resection	1934	DU	Good
I 43	18 yrs	1	Perforated ulcer plication	1927	Perforating DU	Poor
	7 yrs	2	Bilroth II	1934	DU	Good
S 23	7 yrs	1	Perforated ulcer plication	1931	Perforating DU	Poor
	8 yrs	2	Bilroth II	1939	DU	Poor
B 42	17 yrs	1	Perforated ulcer plication	1939	Perforating DU	Poor
	2 mos	2	Bilroth II	1940	DU	Good
B 52	15 yrs	1	Perforated ulcer plication	1936	Perforating DU	Poor
	15 mos	2	PGF	1938	DU	Good
S 38	1 yr	1	Finney pyloroplasty	1932	DU	Poor
	12 wks	2	PGF	1933	DU	Poor
H 49	8 yrs	1	Pyloroplasty	1932	DU	Poor
	6 hrs	2	Pyloric exclusion and PCE for bleeding	1935	DU	Poor
L 27	6 yrs	1	Pyloroplasty and appendectomy	1932	DU	Poor
	5 yrs	2	Bilroth II	1937	DU	Good
S 53	1 yr	1	Excision of GU and PGE	1933	GU	Poor
	4 mos	1	Gastric resection	1939	GU	Good
D A 30	12 yrs	1	PGF	1929	DU	Poor
	5 mos		Pyloroplasty	1933	DU	Good
B 44	5 yrs	1	PGF	1931	DU	Poor
	1 yr	2	Pyloric resection and enteroenterostomy	1933	DU and MU	Good
W 41	14 yrs	1	PGF	1928	DU	Poor
	6 yrs		Dismantling	1934	MU	Poor

\*All cases followed up to 1942

DU Duodenal ulcer GU Gastric ulcer MU Marginal ulcer PGE Posterior gastroenterostomy GCF Gastrocolic fistula

TABLE VI—CASE REPORTS\*—Continued

Case Age (in years)	Duration of symptoms	No.	Procedure	Date	Lesion	Result
B 40	20 yrs		PGE	1933	DU	Per
	20 mos.		Resection	1939	MC	Per
S 41	3 yrs		PGE, excision of GU and tumor, ileostomy	1934	GU and benign tumor	Per
	day		Exploratory laparotomy Gastrostomy	1938	GU	Dead (p)
B 34	1/2 yr.		PGE	1931	DU	Per
	yr		Dismantling	1936	MY	Per
	13		Gastric resection, Billroth II	1937	DU	Good
	yr		PGE	1938	DU	Per
C 34	3 yrs		Dismantling	1934	MC	Per
	3 yrs		Pyloric anastomosis and anterior GJ	1933	DU	Per
	3 yrs		Gastric resection	1940	MC	Good
W 41	3 yrs		Phenol of perforated DU and PGE	1944	Perforated DU	Per
			Phenol of perforated MU Dismantling	1943	Perforated MU	Dead (p)
M, 37	3 yrs		PGE	1935	DU	Per
	3 yrs		Revision of PGE, enlargement	1933	Stomach	Good
S 30	yr		PGE	1930	GU	Per
	1 mos.		Dismantling	1937	MU	Per
	3 yrs		Excision of GU	1938	GU	Per
	20 yrs		Subtotal gastrectomy	1931	DU	Per
34	yr		Polya resection	1939	MU	Good
V 33	6 yrs		PGE	1936	DU	Per
	mos.		Polya resection	1940	MC	Good
O 36	4 yrs		Phenol of perforated ulcer and PGE	1934	Perforated DU	Per
	3 yrs		Dismantling	1939	MC	Good
	3 yrs		Secure perforated ulcer	1940	Perforated DU	Per
B 34	8 wks		PGE	1934	DU	Per
	3 yrs		Pylorotomy	1940	DU and MU	Per
	mos.		Gastric resection	1940	MU	Good
S 33	6 yrs		PGE and appendectomy	1934	DU	Per
	3 yrs		Dismantling gastrectomy ileostomy pyloroplasty	1938	GCF	Dead (p)
B 6	3 yrs		PG	1933	DU	Per
	1/2 yrs		Dismantling GCF	1937	GCF	Good
B 36	3 yrs		PGE	1940	DU	Per
	yr		Dismantling GCF	1940	GCF	Per
	hrs		Phenol of perforated ulcer and PGE	1939	Perforated DU	Per
J 33	4 yrs		Laparotomy	1933	No ulcer	Per
	3 yrs		Dismantling GCF	1937	GCF	Per
	mos.		Polya resection	1938	DU	Dead (p)
O 33	1/2 yrs		PGE	1939	DU	Per
	mos.		Dismantling GCF	1937	GCF	Per
	3 yrs		PGE	1939	DU	Per
	1 yrs		Dismantling GCF	1937	GCF	Per
	yr		Billroth II	1938	DU	Good
	1 yrs		PG	1934	DU	Per
	mos.		Dismantling	1936	MU	Per
30	3 yrs		PGE	1939	DU	Per
	mos.		Dismantling and resection	1941	GCF	Good

# ACUTE CHOLECYSTITIS AND ITS RATIONAL TREATMENT

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**A**PERUSAL of the literature on abdominal surgery during the past few years indicates not only that there has been a growing interest in the subject of acute cholecystitis but also that with this increased interest there has unfortunately arisen much confusion and difference of opinion regarding its treatment. While all are agreed that the ultimate cure of the condition lies in operation, many surgeons advise "immediate" or "early" surgical intervention in order to avert such sequelae as gangrene, perforation and peritonitis, while others, equally experienced, are just as emphatic in declaring their adherence to "delayed" operation as the treatment of choice on the grounds that under conservative management symptoms will often subside and so enable operation to be undertaken at a quiescent period with less risk to the patient.

The cause of this confusion is not far to seek, for it lies in the failure to realize and apply the important fundamental surgical principle that the basis of the rational treatment of any condition is a thorough knowledge and appreciation of the underlying pathology and its correlation with the symptomatology. In many articles concerning acute cholecystitis no mention is made of its pathology, in others, when an outline of this aspect of the disease has been attempted, no effort is made to emphasize its importance or to correlate it with the symptomatology and thus use it as the key to the rational treatment.

The result of this failure is to be seen throughout the literature by the lack of mention of specific clinical indications for operation, for the recognition of these indications as such can be based only upon a knowledge which permits of an interpretation of the symptomatology in terms of the pathology. In place of this rational approach to the problem of "when to operate" it has unfortunately become the accepted custom to attempt its solution in terms of the time factor. Thus the discussion has resolved itself into an argument as to whether operation should be undertaken as an "immediate," "early," or "delayed" procedure (terms which cannot be satisfactorily defined), disregarding the important fact that the rate of progression of the pathological changes which take place in this condition varies in each case to

a greater or less extent and therefore can never bear a fixed relationship to the time factor, for in one case these changes may advance in 24 hours to a stage comparable to that which may not be reached in another for several days. It is true, since operation will be undertaken at some time or another, that the actual time of its performance will naturally fall into one of these categories, but to choose that time because of belief in respective "immediate," "early," or "delayed" operation as such instead of on the basis of specific indications for its performance is not only an irrational procedure, but is likely to lead, on the one hand, to the unnecessary performance of an emergency operation or, on the other, to a delay which might well prove fatal.

## ETIOLOGY AND PATHOLOGY

At the outset it should be realized that there are two distinct factors playing a part in the etiology of acute cholecystitis.

The first is an acute inflammation of greater or less degree involving all layers of the gall-bladder wall, though usually most marked in the submucosa. In many cases the irritant causing this inflammation is of the infective type but in others no evidence of infection can be found on competent bacteriological investigation, as pointed out by Andrews. It follows that in such cases the irritant is of the noninfective type, the most obvious being the trauma inflicted upon the friable mucous membrane by a stone or stones, especially one suddenly impacted in the region of the cystic duct. In recent years another irritant of this type suggested as a possible cause of the inflammatory reaction consists of the ferments of pancreatic juice which has reached the gall bladder by reflux (2, 12).

The second factor is acute obstruction to the outlet of the gall bladder. This is due either to the sudden impaction of a stone in or near the cystic duct, as in most cases, or to the occlusion of this duct by inflammatory edema. The importance of this factor lies in the fact that the special characteristics of acute cholecystitis, both pathological and symptomatic, as we have come to recognize them, arise only when such obstruction takes place. The writer suggests, therefore, that if this condition were to be designated "acute obstructive cholecystitis" not only would this be

correct terminology but it would serve the additional purpose of forcefully reminding the surgeon of a factor which often plays a more important rôle than inflammation in deciding the outcome of the pathological changes.

Since the outlet of the gall bladder is so small, obstruction, should it occur at all, is likely to be complete and even if only partial it is sufficient to interfere materially with the emptying of the organ. In milder cases, however much the assumption of the occurrence of a partial obstruction only may be correct, there seems little room for doubt that in those more advanced, that is, those in which the pathology has been progressive the obstruction is complete. As will be seen later the importance underlying obstruction depends not so much upon its degree for there is little actual difference between the partial and complete varieties because of the small size of the outlet in which it is occurring but upon whether it will, or will not, be relieved.

It is thus necessary that we should know what changes may follow an acute obstruction of the gall bladder. Many years ago Rutherford Morrison, a great teacher drew attention to the fact that when a stone suddenly blocks the neck of the viscus one of three typical conditions follows, depending upon the amount of bile present in the gall bladder when the obstruction takes place (7). These are (1) The gall bladder becomes slowly distended by its own secretion and forms a chronic, painless lump in the right hypochondrium (hydrops of the gall bladder) (2) This distended gall bladder may become the seat of inflammation and there is a tender lump in the right hypochondrium (empyema of the gall bladder) (3) The distended gall bladder becomes gangrenous (gangrenous cholecystitis).

Morrison added the explanation that in hydrops the gall bladder has been emptied by its contraction before impaction of the stone and after the impaction it became distended with its own secretion, while in gangrenous cholecystitis the stone became impacted as a first step, just as the plug in an emptying bath may be swept into its outlet, and the gall bladder thus remained full of infected bile.

It is with the third condition that is, the acute cholecystitis which may terminate in gangrene, that we are here particularly concerned although empyema of the gall bladder may be so acute as to be clinically indistinguishable from it.

The mechanism whereby such a distended gall bladder may become the seat of gangrene is described in a important general principle formulated by Morrison (8). This principle states that

If in any hollow muscular viscus, active inflammation is superadded to obstruction the intra-visceral tension increases and may become so acute as to interfere with the circulation to such an extent that partial or total gangrene ("traumatic gangrene") of the involved viscus, to be followed by rupture and extravasation of its contents, will take place. While the importance of this general principle is obvious, its value is further enhanced by the fact that it can be applied to any hollow muscular viscus.<sup>1</sup>

In acute cholecystitis the gall bladder is the seat of this combination of acute obstruction and inflammation and the essential pathology is that which is indicated in Morrison's principle. The augmentation of the fluid contents of the gall bladder which results in an increase in the intra-visceral tension is brought about by both exudation and transudation into the lumen, the former a result of the inflammatory reaction, the latter through the congestion of the submucosal and mucosal veins and capillaries consequent upon compression of the blood vessels in the wall during the forcible contractions of the unrelaxed muscle, these contractions representing Nature's method of attempting to overcome the obstruction. This compression may also result in extravasations of blood from these veins and capillaries caused by some to be infarcts. It is possible that in some cases the musculature passes into a state of tonic spasm and this occurrence, should it take place, would lead to increased severity of these similar changes. Exudation and transudation also take place into the composite tissues of the wall of the gall bladder, giving rise to the edematous thickening which is such a marked feature of acute cholecystitis. Thus both the inflammatory and obstructive factors are concerned in the production of the increase in the intra-luminal tension. While it may be difficult to estimate the relative importance of the rôle played by each of these factors, yet in some cases the predominance of the inflammatory factor may be readily discernible both to the naked eye and microscopically especially when the irritant causing the inflammation is of the infective type (Fig. 2). On the other hand, in cases in which acute inflammatory changes of mild degree only are found on microscopic examination of the excised gall bladder and its contents, inflammatory exudation can have played but a minor rôle in effecting the increased

<sup>1</sup> of interest that recent articles on the subject of acute appendicitis indicate an increasing realization of the essential part played by obstruction and increased intraluminal tension as above, here also regarded as being solely of an inflammatory nature but not others, however, that this does not hold true in all cases of the appendix. Morrison's principle cannot be more easily than the last Professor Morrison and applicable to all the hollow muscular viscera (14 & 15).

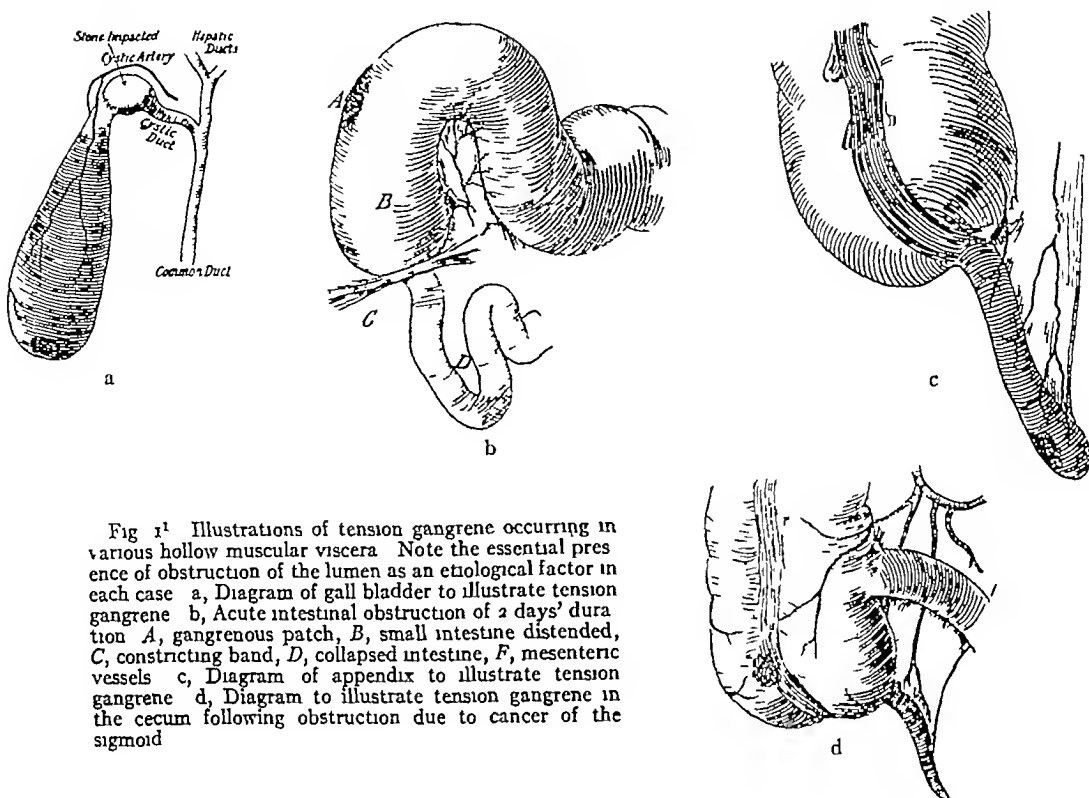


Fig 1<sup>1</sup> Illustrations of tension gangrene occurring in various hollow muscular viscera. Note the essential presence of obstruction of the lumen as an etiological factor in each case. a, Diagram of gall bladder to illustrate tension gangrene. b, Acute intestinal obstruction of 2 days' duration. A, gangrenous patch, B, small intestine distended, C, constricting band, D, collapsed intestine, F, mesenteric vessels. c, Diagram of appendix to illustrate tension gangrene. d, Diagram to illustrate tension gangrene in the cecum following obstruction due to cancer of the sigmoid.

intravisceral tension, the factor chiefly responsible for this being the transudation of fluid into the lumen consequent upon the repeated vascular compression by the forcible muscular contractions (Fig 4). Because the pathological state of the gall bladder can thus vary considerably in acute cholecystitis, attempts have been made to classify this condition into various pathological types (10), but it should be remembered that these variations represent, not separate pathological entities, but only different degrees of severity of a disease consequent upon the same underlying pathology.

The increasing distention of the obstructed gall bladder results in the squeezing of the blood vessels in the tensely stretched wall, thus interfering with the passage of blood through them, and may eventually lead to their complete occlusion with death of the tissues supplied by the vessels so affected. The gangrene which is the outcome of this type of mechanical interference with the blood supply has certain definite features. It always commences at a spot farthest from the

source of vascular supply, for this area is naturally the most vulnerable to such interference, and so, in the case of the gall bladder, it is first observed at the fundus. It appears as a black or grayish, rounded or oval, patch which steadily spreads, its extent depending upon the amount of vascular bed occluded. As might be expected, the mucosa is always the first and most affected, and it is not uncommon, therefore, in early cases to find gangrene of this layer present although the rounded patch, indicating a spread of the gangrene to involve the whole thickness of the wall, has not made its appearance (Fig 2). It should be noted that gangrene may also take place at the site of an impacted stone from direct pressure. Figure 1 illustrates examples of tension gangrene in various hollow muscular viscera and is reproduced to stress its importance in surgery and the possibility of its occurrence, not only in the gall bladder, but in any of the hollow muscular systems of the body.

The theory of Denton that the vascular interference in acute cholecystitis is due to circulatory stasis consequent upon obstruction of the cystic vein and lymphatics by pressure of the stone

<sup>1</sup>(Reproduced from *An Introduction to Surgery* By Rutherford Morison and Charles F. M. Saint, 3rd ed. 1935 by permission of the publishers John Wright and Sons Bristol.)



impacted in the cystic duct is mentioned because many recent writers appear to have accepted its validity without question, although Kreidler's work disproved it completely on anatomical grounds alone. Moreover in some cases no stone is present to account for the vascular interference and, in addition, if a stone is impacted in the duct it is well known that cholecystostomy will relieve the vascular interference even if this stone is inadvertently left behind at operation—it would fail to do so if the vascular interference was due to pressure by the stone upon the cystic vein. Finally this theory can never explain the vascular interference found in other obstructed hollow muscular viscera when the agent obstructing the viscera is so far removed from the main venous and lymphatic trunks that the possibility of its exerting pressure upon these structures does not arise as, for example, in the appendix or cecum (Fig. 3). Its failure to do so at once reveals the limitations imposed by regarding the gall bladder as an isolated entity instead of applying to it the principles governing the hollow muscular viscera in general.

The termination of an attack of acute cholecystitis, whether by resolution, fibrosis, partial destruction or total destruction of the gall bladder would appear to depend more on the obstructive than on the inflammatory element of the pathology for when the gall bladder succeeds in emptying itself the attack usually subsides. In other words, if the obstruction is relieved, with consequent lowering of the intravisceral tension, the more serious terminations of partial or total gangrene are unlikely to occur. This is borne out clinically for these more serious terminations never occur except in cases in which the gall bladder is tensely distended, indicating a failure on the part of Nature to have removed or otherwise overcome the obstruction and so to have relieved the increased intravisceral tension.

#### THE RATIONAL TREATMENT

A study of the pathology of acute cholecystitis makes it clear that once the etiological factors already discussed have come into play and established the disease, the outcome depends upon whether or not the resultant increased intravisceral tension will be relieved. Should the condition be left to Nature, there are two possibilities whereby the tension may be relieved, the first being that the obstruction may be overcome or removed (e. g. the dislodgement of a stone obstructing the neck of the gall bladder) and so allowing the escape of the contents through the natural passages the second, that their escape

will be provided for through a rupture of the wall after gangrene has occurred this catastrophe representing the natural cure of increased tension. In any hollow muscular viscera in the presence of an obstruction which Nature herself is unable to remove or otherwise overcome. Should the first possibility occur then the need for surgical intervention as an emergency measure does not arise, for the patient will recover from the attack. In such a case, elective surgery can be undertaken at a later date. It is in the prevention of the second possibility which materially increases the chances of a fatal outcome, that surgery assumes its important rôle and here following the lead Nature herself gives, the rational treatment consists of relieving the increasing intravisceral tension when it has become apparent that she is unable to do so herself except by gangrene and perforation. The clinical manifestations which warrant this assumption that is, that the pathology has progressed to such a stage, and which therefore indicate the need for surgical intervention if the more serious terminations of the disease are to be prevented, will be considered presently. Judging from the literature, so far as the writer is aware the existence of this pathological stage, as such, has not been realized, although all cases likely have progressed to gangrene most of necessity have passed through it. Once it has been generally accepted and its clinical recognition established, then a definite advance will have been made in the management of acute cholecystitis for this knowledge will tell us clearly the time when operation should be undertaken and so simplify a decision which at present is the subject of much confusion and difference of opinion.

Relief of the tension may be accomplished either by drainage of the gall bladder or by its actual removal, the type of procedure performed being decided at operation, rather than by roentgen, such factors as the general condition of the patient, the local findings at operation and the ability and skill of the surgeon all having to be taken into consideration in making the decision.

#### SYMPTOMATOLOGY IN RELATION TO THE PATHOLOGY

It is not proposed to describe in detail the symptomatology of acute cholecystitis but rather to discuss its special significance as a guide to the progress of the disease and thus to the time when operation should best be undertaken.

It has been pointed out that the disease may progress to a stage when the intravisceral tension has increased to such a degree that, unless it is relieved by surgical means, the pathological

changes are more likely to progress than retrogress, that is, this tension will continue to increase and lead to more and more interference with the blood supply to the gall-bladder until gangrene finally supervenes. From the surgical standpoint, therefore, it is in particular with the clinical recognition of this stage that we are concerned. While we are enabled to follow the progress of any case by observation of certain clinical manifestations, both general and local, the writer has found that there is one in particular, the development of which in the course of a case of acute cholecystitis, transcends all others as an indication that this stage has been reached. It is

*The development of a tender, palpable mass in the right upper quadrant.* If noted early in its development, this mass will present the typical characteristics of a distended gall bladder as regards shape, definition, dullness on percussion and relation to the visceral peritoneum (this structure usually becomes buried in omentum (this structure acting in its capacity of abdominal policeman and as such endeavoring to exclude the source of mischief from the general peritoneal cavity) and the mass, while retaining the gall bladder relations, loses the shape and definition of the free gall bladder and at the same time tends to become more fixed.

Should such a gall bladder be examined, it will be found to present an appearance markedly different from that of the normal viscus (Figs 3 and 4). It is enlarged, the increase in size being partly due to the thickening of the wall by edema but mostly to distention beyond its normal capacity by the increased volume of its fluid contents which may vary from dark looking bile in some cases to frank pus in others. In the early stages, the wall is of a reddish hue and later becomes a plum blue color resembling that of strangulated bowel, while later still the black or gray color characteristic of gangrene makes its appearance beginning as noted previously, at the fundus. It is tense, in contradistinction to the comparative laxity of the normal though distended, gall bladder. If a small incision be made in the fundus, the contents will be expelled forcibly, indicating the increased tension under which they have been present in the viscus in marked contrast to the nonexpulsive, even slow flow of bile that occurs from a distended normal gall bladder similarly opened. It is obvious that the gall bladder could become tensely distended in such a manner only in the presence of an obstruction of its outlet preventing the escape of its increasing contents through the cystic duct. In

flammation, in the absence of obstruction, could not produce this tense distention of the viscus, for the exudate poured into the lumen would be able to escape through the cystic duct. What is the significance of this clinical finding? In the first place, it generally settles whatever doubts there may have existed regarding the diagnosis up to the time of its appearance and, second, it has a bearing of the utmost importance on prognosis and treatment.

Recovery without operation, can be accomplished only by the escape of the fluid contents of the gall bladder through the cystic duct, the increased intravisceral tension being thereby relieved. According to the nature of the obstruction, this would imply such occurrences as extrusion of an impacted stone through the cystic duct into the common duct, disimpaction of the stone which is then free to fall back into the lumen of the gall bladder, diminution of the edema of the mucosa to an extent such as will allow the passage of the contents past a stone in the outlet or, if no stone is present, will open up the previously closed cystic duct, relaxation of muscular effort which may lead to actual dilatation of the duct, with a similar result.

The outcome of these considerations is the question in view of the pathological significance of this clinical stage of the disease, what are the chances of such spontaneous recovery and what are those of progression, *once it has been reached?* The writer is of the opinion that when this stage has been reached the intravisceral tension has become so great that the time has passed when such occurrences as those here mentioned are likely to take place. That the disease has actually progressed to this stage appears to him to indicate either that an obstructing stone has become so firmly impacted that it cannot be moved by natural means or that edema occluding the outlet of the gall bladder is progressive in character, as otherwise this stage would not have been reached. The writer's contention, therefore, based upon the pathology and his clinical experience is that to expect or hope that spontaneous recovery will take place once this stage has been reached, can best be described as wishful thinking and that if the increased intravisceral tension is not relieved by surgical intervention, then progression, with its serious terminations, is much more likely to be the outcome. Thus it is considered that this stage of acute cholecystitis, as typified by the development of a tender palpable mass in the right upper quadrant of the abdomen in the course of the disease is one of crucial importance and significance since it constitutes

a clear indication that the time has arrived when operation should be undertaken as soon as possible with the object of relieving the increased tension within the gall bladder.

It is realized, however, that no doubt some cases which have reached this stage do recover without operation and while this is so yet, apart from the pathology indicating the probability of progression, another cogent reason for operating at this stage is that it is not possible to foretell which case will recover and which will not. It is therefore surely wiser to play for the safety which lies in operative relief of the intravisceral tension since progression to gangrene, even without perforation, diminishes the patient's chances of recovery. There are many surgeons who hold the opinion that operation at this, necessarily acute, stage of the disease, far from being a safe procedure, will assuredly result in a formidable mortality. The writer has never felt that this should be so in the hands of any competent surgeon and, in view of his personal experience (q. v.) he cannot subscribe to this opinion. The high mortalities reported in some series of cases in which operation was done while the disease was in the acute stage appear to him in many instances, to represent the penalty of delay, this stage having been allowed to last too long through the hope or expectation that recovery would take place under conservative measures. Thus in such cases the cause of death is not the operative procedure, *per se*, although this is blamed statistically and quite wrongly for it, but the fact that operation was undertaken at too late a pathological date to obtain the desired successful result.

It is sometimes reported that in acute cholecystitis, when a greatly enlarged, distended, and perhaps gangrenous gall bladder enveloped by omentum, has been found at operation, the presence of a mass in the right upper quadrant could not be elicited on clinical examination. The failure to determine before operation the presence of a mass in such a case is generally attributed to interference with satisfactory palpation by the tenderness and rigidity of the overlying musculature. However because such a mass results in an area of dullness occurring in an otherwise normally resonant portion of the abdomen, and because the rigidity will often be found insufficient to prevent the appearance of a swelling which can be seen by careful observation in a good light, it may be said that, on the whole when a gall bladder has become the seat of the pathological changes referred to the presence of a mass in the right upper quadrant of the abdomen will not usually escape detection by the careful examiner.

Should it happen to do so, then the determination of the pathological progress of the disease necessarily depend upon the interpretation of a mass made of other clinical manifestations, the chief among which will be discussed in the following paragraphs.

The development of rigidity of the muscles in the region of the gall bladder is a physical sign of considerable importance since it represents a reaction of the abdominal wall to irritation of the parietal peritoneum. Not only may it be the first sign to point to disease of the gall bladder as the cause of symptoms of previously doubtful origin, and thus prove of definite diagnostic value, but, more important still, it also indicates a spread of the pathological process beyond the confines of the gall bladder itself. Consequently it is the signal for intent observation for spread of the rigidity or the development of a mass under the rigid muscles. A spread of the rigidity even if apparently no mass becomes manifest, in the writer's opinion, would indicate the advisability of operative interference on the grounds that it signifies a steady progression of the pathological process. In most cases, other signs and symptoms will furnish confirmatory evidence of this progression.

The behavior of the pulse is of the utmost importance, for a continuous increase in its rate is one of the most frequent accompaniments, and therefore one of the most certain indications, of a progressive pathology.

The temperature chart must be mentioned as some writers advise that operation should not be undertaken until the temperature has subsided thereby inferring that great reliance can be placed upon this single clinical feature as a prognostic guide. Unfortunately such advice is not always accompanied by equally emphatic counsel against the necessity of always considering the temperature in conjunction with other clinical manifestations, for a falling temperature may indicate, not improvement, but that the patient's resistance is being overwhelmed by a general toxic consequent upon the local condition. Under these circumstances it is the progression of one or more of these other clinical manifestations which will indicate what is happening. Moreover in the more severe cases the temperature may never rise at all and, indeed, may be subnormal. As the writer's experience of acute cholecystitis has grown he has become more and more impressed with the unreliability of the behavior of the temperature as a guide either to the general or local condition of the patient or to the optimum time for operative interference.

TABLE I—AGE AND SEX INCIDENCE IN 44 OPERATIVE CASES OF ACUTE OBSTRUCTIVE CHOLECYSTITIS\*

Decade	Males	Females	Total
10-19	—	1	1
20-29	—	—	—
30-39	3	—	3
40-49	2	5	7
50-59	3	7	10
60-69	7†	11	18
70-79	1	1	2
80-89	—	1	1
Totals	16	28	44

\*The chief indication for operation in each case was the finding of a tender palpable mass in the right upper quadrant.

†The only fatality occurred in a man aged 66 years following cholecystectomy.

The value of the total and differential leucocyte counts, in some surgeons' minds, appears open to question but the writer has usually found these determinations, when repeated, to tally fairly closely with the clinical progress of a case. As with the temperature, we must remember that a falling leucocyte count, coincident with simultaneous progression of other clinical manifestations, suggests a failing resistance on the part of the patient.

The type of case referred to by Heuer, Mentzer, Touroff, and others, in which an advanced pathological process, with or without a fatal outcome, was accompanied by deceptive minimal symptomatology, has never been encountered by the writer.

#### PERSONAL EXPERIENCE

Since 1930 the writer has had occasion to operate upon 44 cases of acute cholecystitis and these will presently be discussed in some detail. Of these operations, 25 were performed at the Royal Victoria Infirmary, Newcastle-on-Tyne, 9 at the Knight Memorial Hospital, Blyth, Northumberland, 4 in private nursing homes, and 6 at the Santa Barbara Cottage Hospital (Table I). This series, though small in number in comparison with those which emanate from hospitals, has the advantage of representing the experience of a single surgeon in that his opinion alone was responsible for advising the operations and these were all performed by him. Those larger series, referred to, usually represent the work of several or many surgeons who may hold varying opinions on the pathology and treatment of acute cholecystitis. In consequence these reports resolve themselves largely into statistical



Fig. 2 The gall bladder in a case of acute obstructive cholecystitis showing gangrene of the mucosa. The contents consisted of purulent, evil smelling bile under great tension. *Escherichia coli* and a nonhemolytic streptococcus were cultured from both bile and gall bladder wall and microscopic examination of the latter showed marked evidence of acute inflammatory change. The wall was relatively thin at the fundus and a patch of gangrene would soon have appeared in this region. A small stone was impacted at the outlet. Onset of symptoms only 48 hours before operation.

surveys and the conclusions which are drawn from them usually represent nothing more or less than the reviewer's interpretation of the significance of the figures presented.

In each of these 44 cases the chief indication for operation was the finding of a tender, palpable mass in the right upper quadrant of the abdomen, the pathological significance of which clinical manifestation has already been discussed at some length. This physical sign was present in 28 patients when these were first seen either in consultation or on admission to hospital, and immediate operation was advised and undertaken. By an immediate operation is meant one which is undertaken as soon as it can be arranged after the decision to operate has been made, that is, after the short interval which is all that is necessary to carry out whatever preoperative measures may be deemed advisable, such as the administration of sedatives and intravenous therapy, gastric lavage, etc. In the 16 remaining cases, the patients were under observation for a length of time varying from hours to 8 days (11 cases 3 days or less) before this sign became manifest. When,

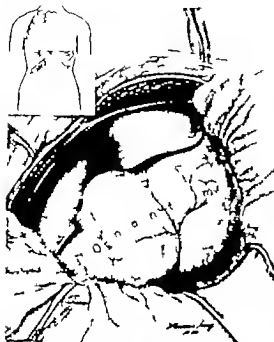


Fig. 3. Exposure of the gall bladder region through Kocher incision (inset) in case of acute obstructive cholecystitis. Shows the characteristic appearance of the omentum enveloping the gall bladder and thus shutting it off from the general peritoneal cavity (From photograph taken at operation.)

but not until, it did so. Immediate operation was advised and undertaken. It is emphasized, therefore that the decision of "when to operate" was not in any way related to any belief or general rule regarding advisability of respective immediate, early or delayed operation as such, but was based entirely upon the development of what are considered specific indications for operative intervention, the chief among these being the finding of a tender palpable gall bladder while other signs such as a spreading rigidity of the overlying muscles and an increasing pulse rate were usual accompaniments furnishing confirmatory evidence of the progressive nature of the pathological process.

The only death occurred in the last case of the series following cholecystectomy so that 1 of 43 consecutive cases patients were operated upon without a fatality. This fact is of importance if for no other reason than proving the fallacy of the statement, often encountered, that operation in the acute stage of acute cholecystitis is likely to be associated with a forbidding mortality rate. However, it is not the writer's wish that by this

fact shall be judged the principles of treatment outlined in this communication, which govern the management of these cases. If they are accepted, rather let it be on the grounds, already emphasized, that they are based on the rational method of approach to the treatment of this or any other acute surgical condition, and an understanding of the pathology and its correlation with the symptomatology. Had other cases occurred to mar this series from the surgeon's standpoint through circumstances which could reasonably be considered beyond surgical control, such as incidental disease or pathology already too advanced when first seen, such fatalities would not in any way have altered his adherence to and teaching of those principles. Indeed, since acute cholecystitis is a disease most prevalent in the later decades of life—in the present series of 44 cases, 3 or 70.5 per cent, were over 50 years of age and 2 or 4.7 per cent, were over 60 (see Table I)—it is unlikely that every one will survive irrespective of whether operation is performed or not or when it is undertaken. The comparison of the mortality rates as the deciding factor on which to base an opinion as to the most propitious time for operation to be undertaken in this acute surgical condition may lead to conclusions which may be not only false but frankly dangerous.

Gangrene of the whole thickness of the gall bladder occurred in 5 of the 28 cases in which a palpable mass was present when first seen and upon which immediate operation was performed. In one of these cases perforation had occurred but the development of the gall bladder by the omentum had prevented the soiling of the general peritoneal cavity. No instance of gangrene affecting the whole thickness of the wall occurred among those patients who developed a palpable mass while under observation and who were operated upon immediately following the discovery of this clinical manifestation but, in several instances, gangrene of the mucosa alone was found to have taken place (Fig. 4).

The frequency with which stones are found to be the cause of obstruction in acute cholecystitis is well exemplified in the present series, for they were responsible for its occurrence in 42, or 95 per cent, of these 44 cases. In the 4 remaining cases no stones were present.

Cholecystostomy was performed in 32 cases and cholecystectomy in the 12 remaining, the preponderance of cholecystostomies being due to the fact that they largely represent the writer's earlier operative experience. The investigation carried out some years ago by the writer (9) on patients

previously subjected to cholecystostomy convinced him that, after an attack of acute cholecystitis, the gall bladder will only resume reasonably good function in a minority of cases and thus converted him to the belief that when the patient's general condition is good and the local findings are such that cholecystectomy can be performed satisfactorily, this is the operation of choice. Consequently, when operation is done in a case of acute cholecystitis, it is now his practice to remove the gall bladder unless this procedure is contraindicated by the presence of some general or local condition, in which case drainage only, with removal of whatever stones may be present, is performed.

The writer has no means of knowing the number of cases, diagnosed provisionally as acute cholecystitis, which have been under his care and which recovered from their attacks without operation, but they certainly exceed in number those upon which operation was performed. In no case which, after the writer's first clinical examination, he decided to observe, did a fatality occur (the only one in this series occurred in a man who already had a tender, palpable mass when first seen and immediate operation was advised), for they either recovered under the conservative measures instituted or, under these, progressed to the stage in which a tender, palpable mass developed and immediate operation was then advised and undertaken successfully. Thus, the patients who recovered without operation, and who formed the majority of those observed, consisted only of those who never progressed to this stage, indicating that, until this stage is reached, the possibility of recovery is sufficiently great to warrant the adoption of conservative treatment unless one is dealing with the exceptional case in which, in spite of a failure to detect a palpable mass, other clinical manifestations indicate a progressive pathological condition. The writer, therefore, considers that to insist that every patient should be operated upon as an emergency is just as erroneous as to declare that all patients should be treated on the "delayed" plan. In no patient in whom a palpable mass developed were conservative measures adopted or continued in contemplation of recovery of the patient from the attack before operation was undertaken—all such patients were operated upon according to the principles of treatment outlined in this communication as no grounds were present for considering any one of them too great a surgical risk. Hence it is impossible to know what results would have been obtained by conservative treatment in these 44 cases after the condition had progressed

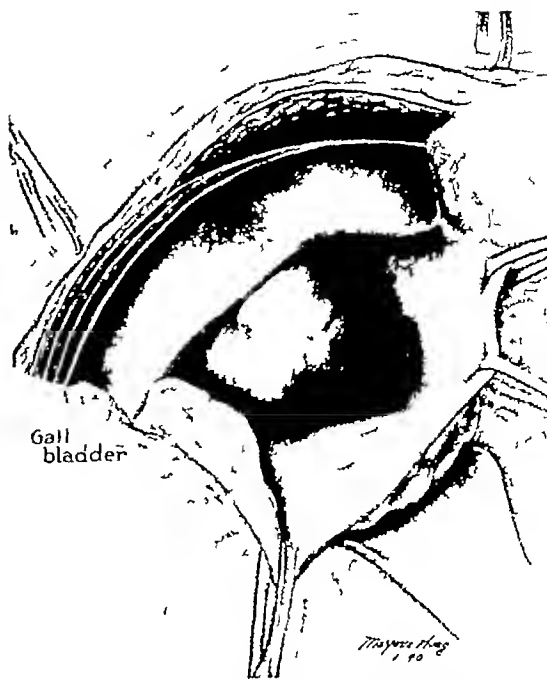


Fig 4 Same case as in Figure 3 showing the omentum peeled off the gall bladder which is grossly enlarged, tensely distended and has a dark colored, thickened wall. The contents consisted of nonpurulent bilious fluid under great tension. Microscopic examination of the wall showed acute inflammatory changes of only minor degree. No stones were present. The fundal mucosa was already gangrenous although only 36 hours had elapsed between the onset of symptoms and operation. (From a photograph taken at operation.)

to this stage. However, the writer has no doubt (when recalling to mind many of those tense, angry-looking gall bladders found at operation) that this method of treatment would not have yielded nearly such satisfactory results as those, already presented, obtained by operation undertaken at this stage of the disease in accordance with the dictates of the rational treatment.

#### SUMMARY

The etiology, pathology, and symptomatology of acute cholecystitis are discussed and from the consideration of these aspects of the disease the following appear to be its outstanding features.

1. While the pathological changes which occur in the gall bladder result from the presence of two factors, namely, acute obstruction of its outlet and acute inflammation of its wall, the rôle played by the former is of such importance as to suggest the desirability of designating the disease "acute obstructive cholecystitis."

2. The essential pathological feature is an increase in the intravisceral tension in the gall bladder the result of this combination of acute obstruction and inflammation occurring in it. This tension may become so acute as to interfere with the blood supply and may do so to such an extent that gangrene ("tension gangrene") of the gall bladder followed by rupture and extravasation of its contents, will take place this catastrophe representing Nature's method of relieving the increased tension within the gall bladder in the presence of an obstruction of its outlet which she is unable to remove or otherwise overcome. Should Nature succeed in overcoming the obstruction then the contents of the gall bladder can escape by the natural passages, leading to relief of the increased intravisceral tension and consequent recovery of the patient from the attack.

3. The rational treatment aims at the prevention of gangrene, and thus of the possible complications of rupture and extravasation, by relieving the increased intravisceral tension through surgical intervention should the disease progress to the stage when it has become apparent that Nature is unlikely to succeed in her efforts to remove or overcome the obstruction.

4. The most important single clinical manifestation indicating that the disease has pro-

gressed to this stage and which therefore informs the necessity for immediate relief of the increased intravisceral tension in the gall bladder by surgical intervention as the most certain means of preventing further progression of the pathological changes to the termination of "tension gangrene," is the development of a tender palpable gall bladder during the course of the disease.

A series of 44 personal cases is presented in which operation was undertaken in accordance with the dictates of the rational treatment. Only one death occurred.

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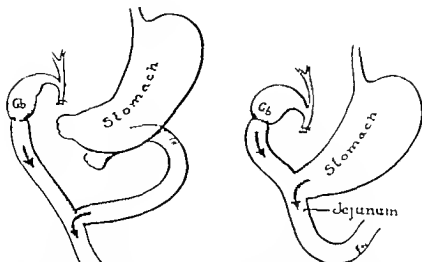


Fig. 1. A diagrammatic line drawing in which the anastomosis done in the Whipple operation of Whipple a, left, is compared with the simplified anastomosis, b, right, herein described. Note that the physiological principles of both are the same.

and blood pressure of 70/1 the epigastrium just to the right of the midportion, tenderness as present on deep palpation but no mass could be felt. The remainder of the examination as negative. Gastrointestinal roentgenograms showed fixation and infiltration of the duodenal loop back suggested mass lying in this region. The impression as carcinoma of the head of the pancreas or mass originating in the duodenal loop.

The patient as quite anemic with hemoglobin of 5 grams, so she as prepared for operation over six day period by rest in bed, high caloric diet, iron and liver and 6 transfusions totaling 3000 cubic centimeters of whole blood.

Operation as done December 24 under ether anesthesia. A tumor as found on the posterior wall of the descending duodenum invading the head of the pancreas but without discernible metastases to the liver. The cleavage plane under the pancreas as followed for short distance below hard gland as left beyond the aorta so that dissection as stopped and plane developed by freeing the greater tissue of the esophagus and aorta. This passed behind the gland. There are large soft glands along the gastrophepatic omentum but these could be removed by clearing all tissue off the bile duct, hepatic artery and portal vein. Palpation of the pancreas showed the head invaded by division of the neck could certainly remove all involved tissue. The duodenum as infiltrated by tumor in its descending portion and appeared to be attached to the pancreatic growth in its third portion. It as decided to do bloc dissection starting below along the esophagus and aorta and above the bifurcation of the hepatic bile duct including in this all of the duodenum and the head and uncinate process of the pancreas (Fig. 1).

The stomach as divided near the pylorus and the proximal part turned back out of the body. The gland bearing tissue of the gastrophepatic omentum as dissected down.

The common bile duct and superior pancreaticoduodenal artery are ligated and divided. Next the transverse colon as lifted up. Its ligament as divided and the duodenojejunal junction as mobilized in the manner described by Lahey. The colon as replaced, and, working

in front of the transverse mesocolon, freed the third and fourth parts of the duodenum by lifting up the middle colic and superior mesenteric vessels and rolling the bowel from beneath them. The duodenojejunal junction as divided and the distal jejunum as turned back out of the body. The inferior pancreaticoduodenal artery as ligated and the head and uncinate process of the pancreas are mobilized. This left the mass of tissue attached only by the neck of the pancreas which as then divided. Here as unexpected difficulty arose, for the neck of the pancreas as found to be only thin sheet of tissue which could not be beveled in V for incision. The cut surface as sutured as carefully as possible, however the closure as not completely satisfactory.

This extensive operation as made easier by the assistance of Dr. Stanley Wedger, our surgical resident, but even so the amount of tissue removed required prolonged dissection. All during the operation were guided by the thought of the gastrointestinal anastomosis to come. When the time arrived to reconstruct the digestive tract I suggested that this could be saved by attaching the upper end of the proximal jejunum to the gall bladder and transplanting the open end of the stomach, end to side, into the bowel below (Fig. 3). This as done and then it as completed the abdomen as closed, wound drainage by the use of silk for suture material.

The patient made satisfactory recovery until her 7th postoperative day when pancreatic juice as evacuated from her wound. A fistula developed which drained about 600 cubic centimeters a day but this gradually diminished until she had daily amount of about 50 cubic centimeters coming from small areas in the wound. This complication as attributed to the difficulty closing the thin neck of the pancreas.

She had episodes of chills and fever between periods of normal temperature for which no adequate explanation could be found in spite of diligent study. She as kept in the hospital for this but she became so desirous of returning to her home that she as finally discharged on her 15th postoperative day. Final diagnosis as carcinoma of the duodenum.

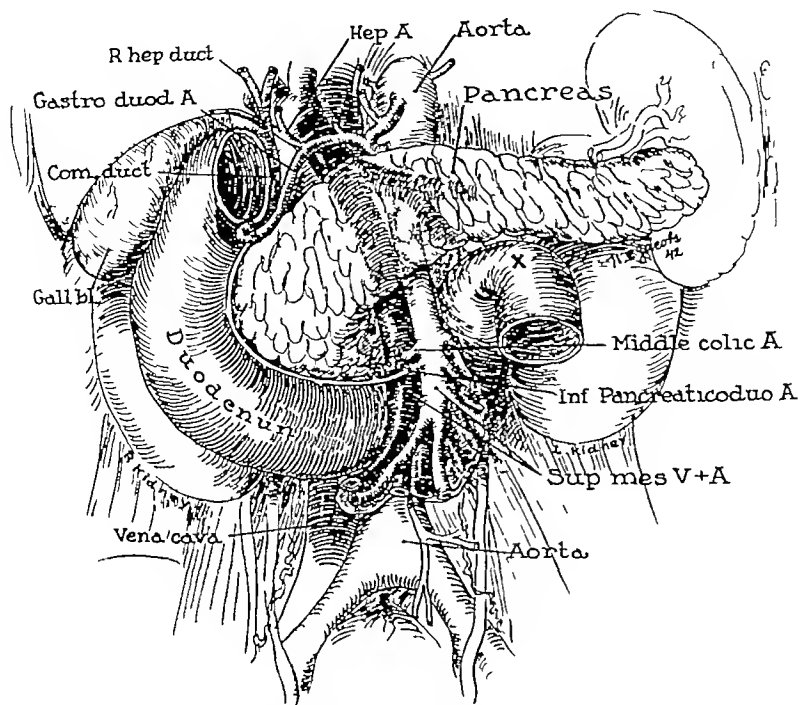


Fig 2 The anatomy of the dissection is shown. When Treitz's ligament is cut and the vessels supplying the fourth part of the duodenum are ligated, the bowel will slip under the superior mesenteric and middle colic vessels. It is easy to do this if the inferior pancreaticoduodenal artery is first ligated and these vessels are lifted up off the duodenum with a retractor. This also assists in exposing the uncinate process of the pancreas. The bowel is divided at X and the distal portion brought up to anastomose with the gall bladder. The pancreas is divided just in front of the superior mesenteric vein.

Soon after this 7 hour operation was started, a cannula was placed in a branch of the great saphenous vein from which blood samples were frequently taken and into which parental fluid and blood were given. This method has been used by Mahoney and allows periodic determination of the hematocrit, specific gravity, and plasma protein. It permits the intelligent administration of saline, plasma, or whole blood and so gives the surgeon assurance of the condition of his patient during such long operations.

The anastomosis here described is only applicable if done in one stage when the entire duodenum is removed. Several cadavers have been studied and in all it was possible to roll the duodenum out from beneath the superior mesenteric vessels. Before this can be done Treitz's ligament must be cut and in some subjects the vessels to the fourth part of the duodenum must be ligated and divided. However, then the mesentery of the jejunum is long enough to bring the bowel to the gall bladder without tension, for this is a shorter distance than in most antecolic anastomoses.

There is advantage in the antiperistaltic attachment of the bowel to the biliary tract, for it offers the best chance of avoiding ascending biliary infection. The operation described would appear to be the simplest way to do this, avoiding as it does the complicated Roux anastomosis. It would seem that the end-to-side gastrojejunostomy is as good as the posterior side-to-side gastroenterostomy and it is much easier to do, for the structures are clearly exposed. It should be placed at least 6 inches from the gall-bladder suture to avoid reflux into that organ.

It might be argued that resection of the entire duodenum is unnecessary and prolongs the operation, but actually it is not hard to do and takes very little time once the anatomy is visualized. It has the advantage of giving a clearer view of the portal vein and pancreas than is obtained in any other way which facilitates the dissection of a region that is difficult to expose under other circumstances.

The resection of the duodenum and head of the pancreas in one stage is applicable only in "good

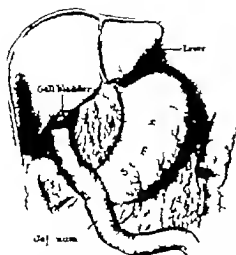


Fig. 3. This drawing illustrates the relation of the jejunum at the end of the operation. Probably more jejunum than is shown should be left between the gall bladder and the stomach to prevent any reflux of gastric contents into the biliary tract.

risk cases. It is much easier and safer to do the dissection in a clean field free from adhesions where the normal anatomical relations are undisturbed. Moreover there is no interference by anastomoses which frequently get in the way during the second stage of resection. But in spite of this, in the presence of debility, cachexia, or severe jaundice it is safer to divide the operative burden into two stages. This may be illustrated by a personal experience. It happened that the day after the operation described an exploratory operation was done on another patient with ca-

cinoma of the ampulla of Vater. Here the growth was small, there were no glands, but there was intense long standing jaundice. Naturally it was desired to repeat the simplified one stage resection but the patient tolerated operative poorly and it was evident that a two stage procedure was preferable so the typical operation of Whipple was done. Even the enthusiasm for new operative technique could not blind one to the obvious advantages of the one stage operation under these circumstances.

#### SUMMARY

A method of one stage resection of the duodenum and head of the pancreas is described which restores the continuity of the biliary and digestive tracts with only two anastomoses. This technique retains the advantage of an antiperistaltic intestinal biliary union but in a simplified form.

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# TENDON TRANSPLANTATION OF THE FLEXOR CARPI ULNARIS FOR PRONATION-FLEXION DEFORMITY OF THE WRIST

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THE functional capacity of the hand is largely dependent upon the ability to extend the wrist and supinate the forearm. If the wrist is in the flexed position, the hand has a very poor grasp and is generally ineffectual. Weakness of the extensor muscles of the wrist and a combined deformity of wrist-flexion and pronation are common in spastic, obstetrical, and infantile paralysis. Any procedure which will correct this abnormal position and allow active extension and supination greatly improves the function of the hand.

Transplantation of the tendon of the flexor carpi ulnaris into the tendon of the extensor carpi radialis longus is an effective procedure in correcting this deformity. It is particularly indicated to aid active extension of the wrist but, since the transplanted muscle is directed around the medial margin of the ulna to be inserted into the radial side of the hand, it is helpful in promoting active supination. The operation has been equally applicable in chosen cases of the three types of paralysis mentioned, and may be indicated in the residual deformity arising from a lesion of the radial nerve.

The criteria and indications for the procedure vary depending upon the original paralytic lesion. Before the operation is contemplated, it should be established that the flexor carpi ulnaris is of "normal" or "good" power, a transplant involving a "fair" or "poor" muscle cannot be expected to function. It is necessary, likewise, that the other musculature affecting the hand should be of sufficient quality to allow satisfactory function after the transplant.

Since a transplanted muscle will not function effectively if it is handicapped by a deformed position, it is essential that the deformity should be correctable passively, at least after the flexor carpi ulnaris is divided. If the deformity cannot be corrected passively, it may be necessary to carry out accessory procedures to allow such correction, either preliminary to or at the time of the trans-

plant. On occasion it has been necessary to divide the tendon of the pronator teres at its insertion, transplanting it from the dorsolateral surface to the volar surface of the radius, and in one case, this was combined with a stripping of a part of the interosseous membrane at its attachment to the radius. Although it has not been necessary in this series, it is likely that osteotomy of the radius and ulna immediately proximal to the wrist joint with or without excision of a small part of the shaft may be desirable as a preliminary procedure to correct the flexion of the wrist in more resistant cases. It is rare that such accessory procedures are indicated in spastic paralysis.

## TECHNIQUE OF OPERATIVE PROCEDURE

The procedure is best carried out, provided the elbow can be extended, with the patient lying in the prone position with the arm abducted at a right angle on an arm board. A longitudinal incision, approximately 2 inches long, is made on the volar surface of the forearm, extending from the pisiform bone upward along the course of the flexor carpi ulnaris tendon. The distal end of the incision should be just proximal to the transverse skin line of the wrist. The tendon is isolated and severed at its attachment to the pisiform. The end of the tendon is grasped with an Allis clamp and freed as far proximally as possible through this incision. The ulnar nerve and vessel may be recognized beneath the tendon (Fig 1). A silk suture of No. 2 braided silk is then introduced into the end of the severed tendon in X fashion.

A second incision, approximately 3.5 inches long, is made over the medial aspect of the forearm over the belly of the flexor carpi ulnaris muscle (Fig 2). This incision should start approximately 2 inches below the medial epicondyle, and is directed distally and dorsally so as to expose not only the belly of the muscle but also the medial edge of the dorsal compartment of the forearm. When the deep fascia is uncovered, the margins of the flexor carpi ulnaris may be defined by traction on the tendon from the distal incision. An incision is then made through the deep fascia over the muscle. The dissection is carried be-

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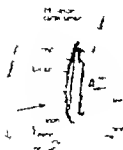


Fig. 1 The first incision over distal end of flexor carpi ulnaris. Insertion in pisiform bone is shown. Tendon is dissected and retracted, exposing ulnar nerve.

neath the muscle distally toward the first incision, freeing its attachment to the ulna in this region as completely as possible.

The suture previously introduced into the tendon is carried from the distal to the proximal incision by means of a tendon passer, and the tendon is drawn into the proximal incision. On occasion, since the ulnaris muscle is attached almost the full distance of the ulna, secondary dissection may be necessary. The short muscle fibers attached to the ulna in the distal portion are sacrificed, as indicated.

The muscle is freed by dissection in a proximal direction so that a straight line may be developed from its origin to its intended insertion into the extensor carpi radialis longus (Fig. 2). The nerve to the muscle must be preserved, but since it enters the muscle in its proximal portion, this is easily accomplished. Through this same incision, the medial dorsal margin of the ulna is recognized. Incision is made through the fascia over the extensor carpi ulnaris muscle, and the dorsal com-



Fig. 2 The site of the second incision may be seen. The inserted drainage lag shows the tendon drawn into the incision, and the muscle freed in a proximal direction.

partment of the forearm is entered (Fig. 3). The periosteum should not be exposed, and the opening into the dorsal compartment should be sufficiently large to allow free entrance of the muscle.

A third incision, approximately 2 inches long, is then made over the course of the extensor carpi radialis longus just below the first joint (Fig. 3). The tendon of the extensor carpi radialis longus is recognized and isolated. A tendon passer is then introduced from the proximal incision through the previously prepared opening into the dorsal compartment and directed down to the third and final incision, along the course of the extensor digitorum communis (Fig. 3). It is brought out adjacent to the extensor carpi radialis longus tendon. The distal end of the flexor carpi ulnaris is then drawn down into the dorsal incision, with care to assure that the muscle and tendon are in no way constricted. The course of the muscle should be essentially a straight line from its origin to the prospective insertion, when the forearm is in supination.

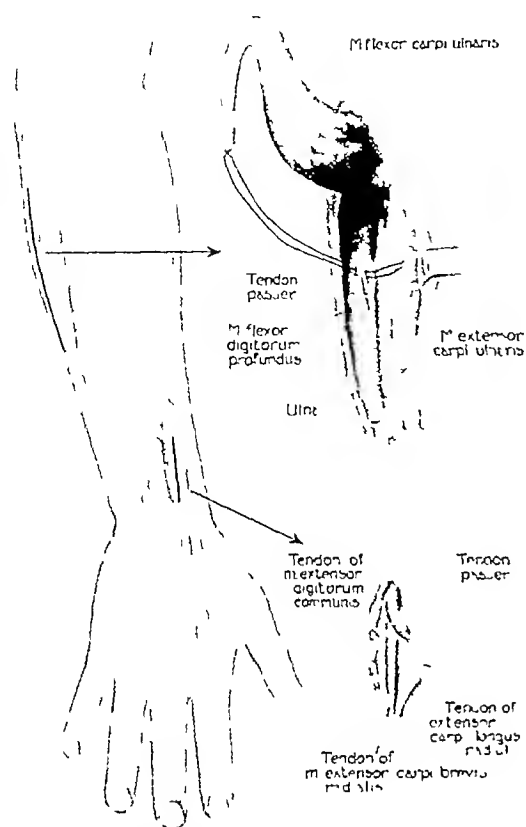


Fig. 3 The third incision exposing tendon of the extensor carpi radialis longus is illustrated. The upper inset shows the tendon passer entering the dorsal compartment of the forearm. Below, the distal end of the passer may be seen coming out alongside the extensor carpi radialis longus.

The tendon of the extensor carpi radialis longus is incised and the ulnar tendon is then sutured into it, with the forearm in supination and the wrist in dorsiflexion (Fig. 4). The tension of the transplanted tendon should be moderate, but it should hold the hand in the corrected position. The arm is immobilized in a bivalved plaster splint from the metacarpophalangeal joints to a point just below the axilla, with the elbow flexed at a right angle, the forearm in complete supination, and the hand in dorsiflexion.

Ordinarily, guided active exercises are started on the third day following operation. The result from the transplant may well depend upon the efficiency of the physiotherapeutic regimen. The training of the muscle to carry out its new function is best accomplished by having the patient attempt ulnar deviation of the wrist as the hand is carried into dorsiflexion and supination, an

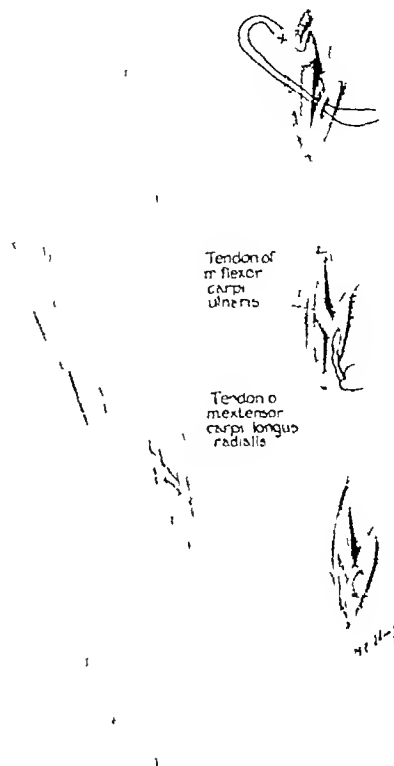


Fig. 4 The transplanted muscle is now in position. The method of insertion into the extensor carpi radialis longus may be seen.

exercise which combines the new function with the old. The hand is held in the corrected position by the bivalved plaster splint for a variable period of time, as indicated. Often a night splint is used for a long period, particularly in cases of cerebral palsy. Removal of the support too early may defeat the function of the transplant, as may cessation of physiotherapy before the transplant is effective.

#### SPASTIC PARALYSIS

In spastic paralysis involving the upper extremity, the hand is frequently in a position of flexion and ulnar deviation at the wrist, with the forearm in pronation. Attempts at extension and supination vary in their effectiveness. In many instances, there is utter inability to carry out these motions. In others, the function is performed in such incomplete fashion that it is ineffectual. Weakness of the extensor muscles of the wrist is usual.



Fig. 5 R. P. patient with spastic hemiplegia. a, left, Illustrates difficulty in wrist extension and supination. b, right, Postoperatively. Status of patient 3 months later.

The flexor carpi ulnaris is often one of the major deforming elements in that it pulls the wrist into flexion and ulnar deviation. The transplant in these instances accomplishes its purpose in a two-fold fashion: division of the flexor carpi ulnaris removes it as a deforming factor; the transplantation of the tendon into the extensor carpi radialis longus increases the power of extension.

R. P. male, aged 9 years, was admitted to the Children's Hospital on April 7, 1940, with spastic hemiplegia, left.

Physical examination corroborated this diagnosis, which had been made previously. Voluntary motions of the left hand and wrist were difficult. Attempted use of the hand provoked increased spasticity with flexion and lateral deviation of the wrist, pronation of the forearm, and hyperextension of the fingers. Active supination, as to neutral only. Passively the parts could be carried through full range of motion. The other upper extremity was entirely normal. Limitation of active supination and extension is shown in the preoperative photograph (Fig. 5a).

Transplantation of the flexor carpi ulnaris to the extensor carpi radialis longus was done on April 24, 1940. Examination of July 7, 1940, showed greatly improved function, as may be seen in the photograph taken at this time (Fig. 5b). Supination lacked only a few degrees of being equal to the other side and active dorsiflexion of 45 degrees as present.

F. C. female, aged 9 years, 9 months, was admitted to the Children's Hospital on July 6, 1940, with the diagnosis

of spastic hemiplegia, left. On previous admission to the hospital, in May, 1934, Scarff's neurectomy of the branch of the median nerve to the pronator teres had been done. This had resulted in little or no improvement.

Examination of the left arm showed poor function in the left wrist with ulnar deviation, limited and weak active extension, and active supination only 30 degrees toward neutral (Fig. 6a). Attempted dorsiflexion and supination were accompanied by many accessory motor activities.

On July 7, 1940, tendon transplantation of the flexor carpi ulnaris to the extensor carpi radialis longus was done. Follow-up examination of March 7, 1941, shows excellent function of the hand in all respects, as may be seen (Fig. 6b). Supination is essentially complete. She had good active dorsiflexion with an excellent grip.

The transplant has been carried out in 25 cases of spastic paralysis. All of these have had an end-result determination varying from 1 to 8 years after the operation. In classifying the result, the criteria were necessarily different from those in a flaccid paralysis, and took into consideration the fundamental motor dysfunction.

Of the 25 cases, all have been improved. In 12, this improvement was recorded as marked, and in 3, moderate.

The operative result has been classified as excellent in 9, good in 4, "fair" in 1, and "poor" in 1. The one recorded as "poor" showed marked

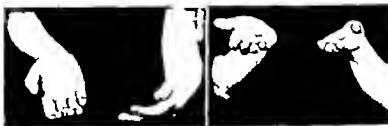


Fig. 6 F. C. patient with spastic hemiplegia. a, left, The limitation of active supination of the forearm and extension of the wrist on the left are shown. b, right, Same patient 8 months after tendon transplantation of flexor carpi ulnaris into extensor carpi radialis longus.

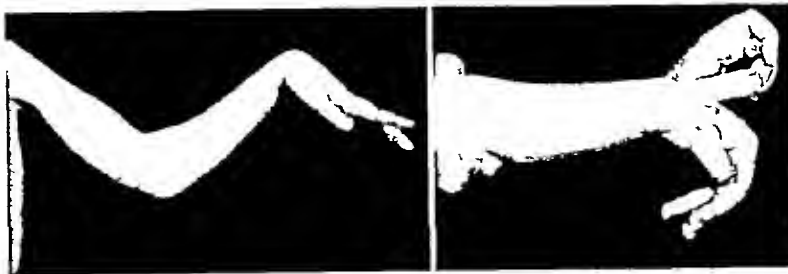


Fig 7 B C, patient with obstetrical paralysis a, left, Photograph illustrates the maximal active dorsiflexion of the wrist b, right, Same patient 6 years after operation Phantom photograph illustrates range of active flexion and extension of wrist Excellent function of hand

spasticity with minimal control. In this case there was definite improvement in function from the procedure, but subsequently a fusion of the wrist was done with little further improvement. The patient recorded as having a "fair" result showed marked spasticity with minimal control, and was mentally retarded.

Of the 4 in the "good" group, 2 showed quite marked spasticity, 1 was mentally retarded, and the other showed excellent function of the transplant, but the capacities of the hand were limited by an adduction deformity of the thumb which had not yet been corrected.

In 2 of the patients, a neurectomy of the branch of the median nerve to the pronator teres had been done several years before with little effect. In 1 of these, it was our impression that the hand would have had better function if the preliminary neurectomy had not been done, since there was weakness in pronation after the transplant, which we associated with the previous operation. In 1 instance, a neurectomy was done at the same time as the transplant, and in this case the result was excellent.

In those cases in which the extensors of the fingers have been rated as "poor," it has been questioned whether the transplant should be inserted into the extensors of the fingers, or into the extensor of the wrist. Usually the choice has been to place the transplant into the wrist extensor, and, subsequently, with the wrist in the improved position and with muscle training, the extension of the fingers has been very satisfactory. In a few cases not included in this series, the transplant has been inserted into the finger extensors with satisfactory result.

Adduction of the thumb is quite a common deformity in spastic paralysis. Often with the improved position of the hand following the operation and with muscle training, further procedures are not necessary. An adequate trial should be

given after the operation before an operative procedure on the thumb is performed.

The transplant is least effective when the spasticity is very marked and the patient has little active control of the hand. It is not indicated in the presence of gross mental deficiency.

#### OBSTETRICAL PARALYSIS

In obstetrical paralysis of the "whole arm" type with partial recovery of the hand, the extensors of the wrist may be the only muscles which do not have a return of power. It is in these instances that the operation is particularly indicated, although it may be helpful in other cases in which the residual paralysis is more extensive.

B C, female, aged 11 years, 10 months, was admitted to the Children's Hospital September 5, 1934, because of functional incapacity of the left arm dating from birth. She had been admitted to this hospital on two previous occasions, and a diagnosis of obstetrical paralysis of "whole arm" type had been made. At one admission, on October 11, 1928, she had had a Sever procedure, that is, a division of the subscapularis and pectoralis major tendons, as well as the origin of the short head of the biceps and coracobrachialis muscles.

On physical examination, the child had marked disability of the left arm and hand (Fig 7). The hand lacked 30 degrees of reaching the neutral position in active extension although it could be passively extended to neutral. Active supination was limited to 20 degrees. The motion of the fingers was good, although their function was poor, due to the flexion-deformity of the wrist.

On September 8, 1934, the flexor carpi ulnaris tendon was transplanted into the extensor carpi radialis longus. The arm and forearm were held in the corrected position by a bivalved circular plaster splint. Physiotherapy was started 5 days after the operation.

Follow up examination of June 26, 1940, almost 6 years later showed 60 degrees of active extension of the wrist with flexion of 30 degrees (Fig 7). The hand at this time had excellent function in all respects, although there remained some limitation in supination.

This transplantation has been done on 6 cases of obstetrical paralysis, with improvement in all. The end-result was recorded as "excellent" or





Fig. 8. J. L. patient with anterior poliomyelitis. a. The photograph is poor but illustrates the absence of active dorsiflexion of wrist and the presence of fixed pronation

b and c. Same patient, years after operation. Photographs illustrate the degree of active supination as well as range of active flexion and extension of wrist.

good in 4, fair in 1 and "poor" in 1. The patients in whom the "poor" and "fair" results were obtained had external palsy affecting the forearm and hand and the transplanted muscle was recorded as not better than "fair plus" in power before the operation.

#### ANTERIOR POLIOMYELITIS

In our series, the indication for this procedure in infantile paralysis has been less frequent than in spastic and obstetrical paralysis. It is a little unusual to have a "good" or "normal" flexor carpi

ulnaris associated with paralysis of the extensors of the wrist, and yet with sufficient power in other muscles to allow unimproved function by this procedure. When indicated, it has been helpful indeed.

J. L., male, aged 4 years, 5 months, admitted to the Peter Bent Brigham Hospital on October 3, 1935, with complaint of disability of his right arm from anterior poliomyelitis, which he had developed in August, 1927.

On examination, there was complete atrophy on the right with no active extension against gravity, and marked pronation contracture amounting to 45 degrees, with very little active supination.

Muscle examination of the forearm and hand showed the extensor carpi radialis and extensor carpi ulnaris to be rated "poor"; the finger extensors, biceps, and supinator brevis were "fair" and the triceps as "poor." The other muscles affecting the forearm and hand were "good" (normal). The preoperative photograph is poor but does suggest the function of the hand (Fig. 8a).

On October 26, 1935, transplantation of the flexor carpi ulnaris into the extensor carpi radialis was done. In addi-

tion, in order to relieve the pronation contracture, it was necessary to divide the pronator radii teres. It is located on the dorsolateral aspect of the radius, and attached to the anterior surface of the radius after the hand had been supinated. The interosseous membrane was stripped from the radius over a part of its extent in order to derive further the pronation contracture.

Follow-up examination of December 6, 1936, showed excellent dorsiflexion amounting to 60 degrees with almost complete active supination. The grasp, which previous to operation had been poor indeed, was excellent. Another photograph (Fig. 8c) shows the range of flexion and extension of the wrist.

The procedure has been performed in only 2 instances of infantile paralysis. The result in the case just presented must be rated as excellent, and in the other case the result as good.

#### SUMMARY

The function of the hand is greatly impaired by a flexion-pronation deformity of the wrist, a condition which is common in spastic, obstetrical, and infantile paralysis.

Tendon transplantation of the flexor carpi ulnaris into the extensor carpi radialis longus is an effective procedure correcting this deformity and in promoting active extension and supination in cases which satisfy certain proper criteria.

3. This transplant has been done in 23 instances: 15 were in spastic paralysis, 6 in obstetrical paralysis, and 2 in anterior poliomyelitis. The majority were greatly improved.

# REDUCTION OF THE PERMANENT PARTIAL DISABILITY OF COMMINUTED FRACTURES OF THE LOWER END OF THE RADIUS BY SKELETAL TRACTION

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COMMUNUTED fractures of the lower end of the radius are serious. With the accepted treatment they consistently heal with a lamentable high percentage of permanent partial disability. This disability is the result of shortening of the radius with a radial deviation of the hand and resulting pain. In an attempt to remedy this situation we use a method of skeletal traction. In most instances we believe that we have overcome this disability.

Working from the premise that the lower end of the comminuted radius compressed upon itself because of muscle spasm, we felt that by overcoming the spasm the fragments would heal with the length of the radius unimpaired, and consequently the radial deviation of the hand and pain would not develop.

The banjo splint with direct or indirect traction going through the joints of the thumb has previously been proved unsatisfactory because of



Fig 1 a, Comminuted fracture of the distal end of the radius, b, satisfactory result following conservative treatment after 4 months. Patient allowed 15 per cent permanent partial disability as compared to an amputation at the wrist.



Fig 2 a, Comminuted fracture of the distal end of the radius, b, End result after 6 weeks. Note restoration of length of radius and hole left by Kirschner wire in the first metacarpal bone, c, End result after 7 1/2 months. No permanent partial disability awarded.

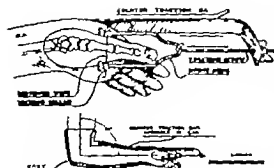


Fig. 3. Schematic drawing showing method of applying traction. The cast is molded beneath the fracture with slight valgus and strong ulnar deviation of the hand.

joint damage. However skeletal traction through the first metacarpal seems to have the necessary requirements with the minimum of disagreeable points.

Under general or local anesthesia the fracture is reduced as much as possible by manipulation. With the hand in slight valgus and strong ulnar

deviation a circular cast from the metacarpophalangeal joints to above the elbow is applied. The cast is widely removed about the thumb. A Kirschner wire is then placed transversely through the distal end of the first metacarpal, care being taken to avoid the joint surfaces. A special brace shoe which allows free motion of the thumb is attached to the wire and held in place by two locking collars. Traction is applied by a threaded screw with countertraction being maintained by an L-shaped bar imbedded in the cast (Fig. 3). The normal length of the radius can be maintained by exerting sufficient traction through the first metacarpal bone. Traction is maintained for 6 to 8 weeks, after which the future cure is dependent upon the amount of healing. In no instances have we been required to maintain further traction. It can be seen that the convalescent period is slightly prolonged, but we feel that our results justify the means. The morbidity otherwise is not increased.

Figures 2a and 2b show the usual result following the accepted method of treatment. Like Figures 2a, 2b and 2c show a typical case following the use of bone traction.

# A MODIFICATION OF THE HIGGINS TECHNIQUE FOR URETEROINTESTINAL ANASTOMOSIS

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IMPLANTATION of the ureters into the bowel presented a problem which all but defeated the earlier operators. The present status of relative success is attributable to the genius of Coffey, who 30 years ago, developed the technique of oblique submucosal implantation based on the valve principle. The obvious advantages of this procedure stimulated new interest and made ureterointestinal anastomosis justifiable. With increasing experience based on more than a thousand such operations, this procedure has become firmly established and its application has been extended beyond cases of exstrophy and carcinoma of the bladder to include epispadias, tuberculous cystitis, Hunner ulcer, vesicovaginal fistula, and similar conditions. Maximum results are achieved by operative intervention, before the ureters are dilated and the kidneys damaged by infection. The simpler surgical procedures involving minimal trauma to the ureter and intestine are recognized as best.

The first two of Coffey's methods are more frequently employed than any other. The results are fairly satisfactory, but the limitations to a unilateral anastomosis with the first and the inapplicability to ureters smaller than No. 10 F plus the complicated equipment and postoperative care necessary for the second are decided disadvantages. To these must be added the likelihood of the development of urinary sepsis. More than 60 techniques have been advocated for the correction of these conditions. Many are based on lateral anastomosis of the ureter and the mucosa of the bowel with immediate or subsequent formation of a fistulous opening. Ingenious methods and special electrocoagulation devices have been utilized for this purpose. It seemed to us, at least in theory, that a satisfactory fistulous opening would be more likely to result from properly and accurately placed sutures than from the secondary use of electric cutting devices, provided the technique insured the immediate and continued adequacy of the stoma.

In 1933 Higgins first published a description of his principle of the "intact ureter" operation. His

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Read before the Genito-Urinary Section, New York Academy of Medicine, November 18, 1941.

work as well as that of Coffey and others proved that a fistula can be established between the ureter and the colon without opening into the intestinal lumen. The advantage of the Higgins procedure is that one stage bilateral implantation without interruption of urinary excretion is feasible. The advantages over the two stage operation are obvious and in cancer may be life-saving. The possibility of delayed, partial or complete occlusion of the fistulous stoma has operated to prevent the more general adoption of this procedure. An instance from our experience, illustrative of this, involved a child who was successfully operated upon by the Higgins technique for congenital absence of the bladder neck. During the following 3 years, gradually increasing dilatation of the ureters and pelvis was observed, and death resulted from bilateral stenosis at the sites of implantation.

With the object of obtaining a more widely patent and permanent fistulous opening, a series of studies involving the placement of the necrosing sutures was carried out. It was ultimately observed that single sutures introduced either transversely or longitudinally in the ureter produced fistulas which were not as satisfactory as those resulting from crucially placed ones. To secure the advantage accruing from cruciform sutures, the following technique was developed.

A small rubber catheter with terminal and lateral eyes is prepared in advance by suturing a few thicknesses of vaseline gauze to the shaft for a short distance proximal to the lateral eye. When induction of anesthesia is complete, this catheter is introduced into the rectum. After the usual skin preparation, the exstrophic area is isolated from the field by a sheet of sterile rubber dam, the upper margin of which is secured to the skin with skin clips and collodion. The patient is placed in the Trendelenburg position, a midline incision is carried through the peritoneum, and extended the full length of the wound. The intestines are displaced upward and supported with moist laparotomy pads.

The right ureter (Fig. 1) identified through the peritoneum as it courses downward over the sacral notch, is exposed by sharp dissection and mobilized for approximately 2 inches. A site in

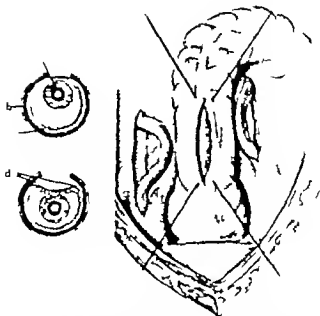


Fig. 1. Exposure of ureters. Mesocolon exposed by longitudinal incision in rectosigmoid so as to form trough. Tension sutures in place. a, Rectal catheter; b, serosa and muscularis; c, mesocolon undermined; d, make space for ureter.

th rectosigmoid, adjacent to the exposed ureter is selected and 4 silk traction sutures are placed, 2 on either side of the linea alba one pair  $\frac{1}{2}$  inches above the other. While moderate traction is exerted on these sutures and the bowel wall is stretched over the tube  $\frac{1}{2}$  inch longitudinal incision is made through the serosa and muscularis to the mucosa. The superficial layers are next undermined to form a trough through the mucosa being left intact. One should bear in mind Coffey's warning that damage to the vessels in this structure may result in sloughing of the mucous layer.

The ureter (Fig. 1) is placed in the trough and steadied by the traction sutures in such a manner that kinking and tension are avoided. A silk suture is then passed transversely through the lumen of the ureter and through the mucosa of the rectosigmoid including in its bite the gauze around the rectal tube before it emerges. It is best placed at the lower angle of the intestinal incision. A similar suture is placed in the long axis of the ureter at right angles to the first, through the lumen of the ureter, the mucous membrane of the bowel, and the gauze. The second suture is looped through the first and both are tightly tied. Thus not only are the ureter and sigmoid doubly an-

chored, but the resulting necrosis as the sutures cut through provides a relatively large fistula, quadrilateral in shape (Figs. 3 and 4). The mucular and serous layers are approximated over the ureter by interrupted silk sutures and the lateral tension sutures are used as a reinforcement. The wound in the bowel is partially extraperitonealized by suture of the outer edge of the posterior peritoneum to the intestinal wall. We have not found complete extraperitonealization essential since limited motility of the bowel is desirable as Lower has stated. After a similar procedure is carried out on the left side sulfathiazole powder is freely dusted on the peritoneal surfaces and the anastomosed areas. The abdominal wound is closed in layers, tension sutures are inserted, no drainage is used.

Attempt to eradicate renal infection, if present, and improve renal function should be carried out as part of the preoperative preparation. The sulfonamide drugs are well tolerated by these patients and their administration in more recent cases before and during the operative period has been helpful. The postoperative course, the absence of extraordinary complications is usually uneventful. Fluids are withheld by mouth for 24

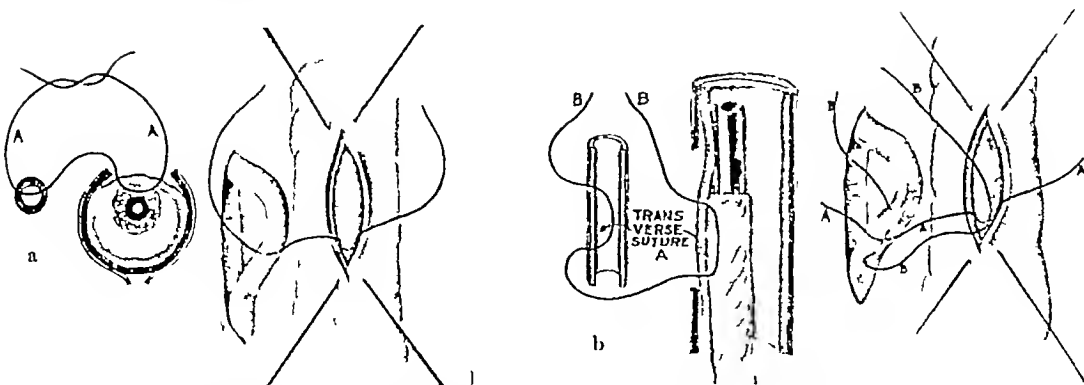


Fig 2 a, Insertion of transverse suture through ureteral wall, mucosa of bowel, including in its bite grieve covering

rectal tube b Introduction of similar longitudinal suture at a right angle to first

hours but freely administered by clysis and intravenous drip. The rectal tube is kept open by frequent small injections of normal saline solution and comes away, as a rule, within a week. In the interim, excretion from the ureteral orifices is variable but has been adequate. After the exit of the rectal tube, drainage from the bladder diminishes considerably. In some individuals the exstrophic area has been practically dry at the end of a few weeks, thus indicating the establishment of adequately patent fistulas. The resulting absence of soiling facilitates nursing care, and permits delaying the removal of the bladder in the event that this step must be deferred. Thus the time for cystectomy becomes optional rather than imperative. Successive postoperative urographic studies have demonstrated that the immediate dilatation of the ureters and pelvis following

neostomy gradually diminishes during the first few months, and even over longer periods of time.

CASE 1 A D a 2 year 9 month old male was admitted to our hospital on April 14 1939 with congenital exstrophy of the bladder and an unexplained anemia. The urine on microscopic examination showed a trace of protein and 10 white blood cells and an occasional clump per field. The blood count revealed a marked secondary anemia. Chemical blood studies showed values at the upper limits of normal. Urography showed a separation of the symphysis pubis, rotation of the left kidney and tortuous ureters with dilated lower portions.

He was sent home for tonic treatment in an effort to improve his general condition and was returned June 10, 1940,

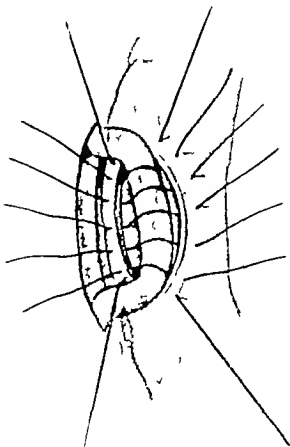


Fig 3 Ureter in trough with crucially placed sutures tied tightly. Sutures for embedding ureter in place



Fig 4 Bilateral implantation of ureters with muscularis sutured. Peritoneal edge to be sutured to bowel



Fig. 5. Case A. D. Intra-eneous urogram before operation. No rotation of left kidney.



Fig. 6. Case A. D. Intra-eneous urogram 7 months after ureteral implantation.

at each time there was no appreciable morphological change in the program though the contrast medium appeared in slightly greater concentration (Fig. 5). Ten days later bilateral implantation of the ureters into the sigmoid was carried out with the use of crucially placed sutures. His immediate postoperative condition was fair. Chemical blood studies showed a rise of urea nitrogen from 34.5 the day after operation to 52.5 on the second day. On the 4th day it was 40. Thereafter it dropped gradually reaching 30 on the 6th postoperative day when the rectal tube came out and remained slightly elevated for 2 months. The excretion from the ureteral orifices in the bladder continued to decrease. Twenty-five days after anastomosis intra-eneous urography revealed slight dilatation of the right kidney pelvis and calices, moderate dilatation of the left pelvis and calices, moderate dilatation of both ureters with good concentration in the sigmoid.

The child readmitted for cystectomy 2 months later for the implantation. The postoperative stay was prolonged by delayed healing of the wound. An intra-eneous urogram, 3 months later, revealed the right kidney pelvis to be slightly dilated with further blunting of the minor calices. The left kidney, as rotated, its pelvis moderately dilated, with increased dilatation and blunting of the calices. The left ureter was considerably dilated and displaced to the left. Contrast medium was seen in the distal sigmoid and the rectum.

The patient, on discharge, was in good condition. A recent intra-eneous urogram, 7 months after the ureteral implantation (Fig. 6) shows the right ureter and pelvis to be almost normal. On the left side there is less dilatation than on the previous examination.

CASE F. R. 4 year old male with entropion of the bladder, as admitted to the hospital on May 6, 1941, for implantation of the ureters into the sigmoid. The laboratory findings were as follows: urinalysis showed urine to be hazy, straw alkaline, no red blood cells per high power field, 5 to 8 blood cells per high power field with many clumps, 4 plus acetone. Chemical examination of the blood showed no abnormality. Intravenous urogram revealed congenital maldevelopment of the pelvic bones. The pelvic portions of the ureters are deflected laterally.

On May 9, 1941, bilateral implantation of the ureters into the bowel by the crucial suture method was performed.

Chemical blood studies showed an elevation of the urea nitrogen to 33 on the second postoperative day with gradual reduction to normal on the fourth day.

On the 26th day after operation, an intra-eneous urogram revealed good function of both ureters with moderate dilatation of the right renal pelvis and dilatation and blunting of the calices of both kidneys. The child was discharged 57 days after implantation with only slight excretion from the ureteral orifices. He was readmitted for cystectomy 67 days after the implantation, the bladder being dry for some time. On discharge, as successful and he was discharged on the 55th day after removal of the bladder. An intra-eneous urogram made just before his last age showed marked reduction in function of the left ureter, the left kidney pelvis and calices, with decrease on the right side.

The intra-eneous urographic studies in this case again demonstrate the progressive improvement



Fig 7 Case 4, D G Intravenous urogram after implantation of right ureter. Right kidney functionless, left shows advanced hydronephrosis



Fig 8 D G Intravenous urogram after implantation of left ureter. Right side functionless, left shows recession of hydronephrosis

of the ureters and pelvis for the first few months following implantation. Previous infection may have been a factor in the dilatation noted in the first series after operation.

CASE 3 W M, a male child, 3½ years old, was admitted on June 16, 1941, with exstrophy of the bladder. At this time intravenous urographic studies revealed faulty development of the pelvic bones and normal morphology of the upper urinary tract. Due to an upper respiratory tract infection, operation was deferred to July 1, 1941, when anastomosis was carried out on the right ureter by the method described. The operation was terminated at this point because of the child's general condition. Convalescence was uninterrupted. Two weeks later, in implanting the left ureter, the mucosa was inadvertently incised while making the trough due to distortion of the sigmoid by the first operation. The repair created an angulation of the ureter which apparently interfered with its patency. For several days following operation there was a rise of temperature without evidence of peritonitis. Small doses of sulfathiazole relieved the symptoms. An intravenous urogram 2 weeks later showed the presence of contrast medium in the right urinary tract at the end of 5 minutes with fairly normal morphology on this side. The medium was discernible on the left side at 15 minutes, increasing in concentration on later exposures. There was marked dilatation and blunt

ing of the calyces on this side. Cystectomy was deferred to a later date and the patient was discharged from the hospital with no leakage from the right ureteral orifice and only a slight amount from the left. At this time intravenous urograms indicated adequate excretion into the sigmoid. This case illustrates the oft repeated dictum that implantation must be precise and technical errors may prove disastrous.

CASE 4 D G, a female child, was admitted to the Jersey City Medical Center on February 27, 1941, with a diagnosis of exstrophy of the bladder. On physical examination, the patient appeared chronically ill. Laboratory findings were as follows: urine negative but for occasional white blood cells on microscopic examination. Blood count revealed a secondary anemia.

On March 7, 1941, the right ureter was implanted into the lower bowel extraperitoneally by the attending urologist. Immediate postoperative condition was fair. Nine days after operation patient developed a fecal fistula which eventually closed. About 1 month later she contracted chicken pox and shortly afterward measles, but these two conditions subsided. Examination of the wound at this time revealed a large ventral hernia. On the 56th postoperative day an intravenous urogram (Fig 7) revealed an advanced hydronephrosis on the left side, and failure of excretion on the right. At this time the general condition of the patient was fairly good and continued to improve until 3 months later, when a left uretersigmoidostomy



as performed, using crucially placed sut res. Conal crence proceeded without complication. On the 5th post operative day the rectal tube came away, the feces became watery and it was noted that very little urine excreted from the ureteral orifices. The patient was discharged on her 5th postoperative day to be readmitted later for excision of the bladder. Ten months later ureterogram (Fig. 8) showed good function, the marked decrease in the ky drocephalus on the left side with complete lack of malrotation on the right.

This case illustrates that a grossly dilated ureter may improve after implantation.

Experience with this method has shown that it fulfills the essential requirements of lateral anastomosis. It is relatively simple and both sides may be done at one sitting without interruption of the flow of urine along the ureter during the period of formation of the fistula. The caliber of the fistulous opening is not limited to that of the lumen of the ureter because the longitudinal sutures increase the aperture to an adequate size. We agree with Higgins, Lower and others that operative intervention in infancy is better than indefinite delay with the results and development of obstructive uropathy and infection. Sulfathiazole and other chemotherapeutic remedies, administered orally and applied locally at the operative site have proved of inestimable value and recent reports of the efficacy of sulfaguanidine and allied agents as intestinal antiseptics indicate that they should prove a valuable supplement to present preoperative and postoperative care. Our immediate results have been favorable. We hope

that time and experience will demonstrate that the eventual outcome of these cases will be equally satisfactory.

#### CONCLUSION

1. A modification of the Higgins technique is presented.

2. The use of crucially placed sut res forms the fistulous opening between the lumen of the ureter and the sigmoid.

3. The resulting stoma is larger than can be obtained by single suture method.

4. There is no apparent loss of the sphincter action of the mucosa.

5. The marked diminution in amount of leakage from the ureteral orifices as soon as the stoma is formed indicates that the fistulas are of adequate size.

6. The resultant absence of soiling makes the time of removal of the bladder optional.

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# PRIMARY ADAMANTINOMA OF THE ULNA

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PRIMARY adamantinoma of the long bones is an extremely rare entity. Rankin, in 1939, reported the eleventh case of this tumor arising in the tibia. We believe the case of adamantinoma of the ulna recorded here is the first reported instance of the occurrence of this tumor in a long bone other than the tibia.

Adamantinoma or adamantine epithelioma is an infiltrating epithelial tumor, arising from basal cells, which grows in a stroma of fibrous tissue, and reproduces, to a certain extent, the histological characteristics of the primitive tooth bud. In the jaws it is a relatively common tumor. Cases have also been reported of this growth's arising in Rathke's pouch and invading the sphenoid bone.

Theories of origin are interesting, even if of little practical importance. In the jaws and in Rathke's pouch, this tumor probably arises from undifferentiated blocks of basal epithelium which developmentally, normally invaginate the underlying mesenchyma and preosseous tissue. In the long bones, the situation is quite different, and two theories have been advanced to explain the origin of primary adamantinoma in these bones. Fischer assumed the origin of such tumors to be in cell rests. This was based upon his belief that if the tumor cells were implanted at a time later than the fetal period, the potentiality to differentiate into tooth-like structures would not be present, and that pavement epithelium would result.

Ryrie, on the other hand, believes that the tumors arise from basal cells implanted in the deeper structures at the time of an injury. Even if the skin is unbroken, the deeper tissues and skin appendages, such as hair follicles, are torn, and implantation could result. It is interesting to note that in all of the reported cases, the patient recalled a severe blow to the long bone at the site of the ultimate tumor. This theory would seem to be further substantiated by the occurrence of adamantinoma in superficial long bones where the skin is closely apposed to the periosteum and where trauma is frequent. Our own feeling is that the theory of implantation is probably correct, and we suggest that perhaps the environ-

ment, i.e., bone, in which the basal cells are implanted is the determining factor in their differentiation into an adamantine tumor. This would seem to afford the opportunity for some enlightening experimental work in the fields of animal research and tissue culture.

Pathologically, the tumor is a soft, spongy, grey, indistinctly lobulated, vascular growth which occupies the central portion of the shaft of the bone and expands it without breaking through the cortex. Microscopically it is an infiltrating epithelial tumor in a stroma of fibrous tissue.

The epithelial elements are derived from a basal type of cell and may approach either squamous epithelium or enamel epithelium. These cells are arranged in tongue shaped or branching pseudo-acinar processes which contain two distinct cell types, both of epithelial origin. The peripheral cells are of the cuboidal or tall columnar type, arranged in one or more layers with their long axes perpendicular to the limiting membrane of the cell group. These are comparable to the ameloblasts of the tooth bud. The central cells are of a cuboidal or transitional type with branching and anastomosing cytoplasmic processes which give a definite stellate appearance. This tissue represents the primitive enamel pulp. Cystic spaces are commonly present in the central area of the aggregations of cells. These may arise as a result of degeneration of the centrally placed stellate cells, so that the spaces are often filled with an amorphous coagulum and cellular debris.

The stroma is made up of fibrous tissue of varying degrees of density. Multinucleated giant cells are frequently present and may represent osteoclasts. A few inflammatory elements are sometimes found.

Clinically, adamantinoma of the long bones exhibits the following characteristics. Being a basal cell tumor, it possesses a limited type of malignancy. Once it is established in a bone, it may erode it to a considerable extent, but does not have the ability to invade adjacent tissues or to metastasize. Cases which recur after incomplete removal may involve surrounding structures. Either males or females may develop the tumor. The age incidence in reported cases is from 22 to 46 years. The chronicity and slow growth of the tumor are noteworthy, the time

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performed, using crucially placed sutures. Concomitance proceeded without complication. On the 5th postoperative day the rectal tube came away the feces became tarry and it was noted that very little urine excreted from the ureteral orifices. The patient was discharged on her 5th postoperative day to be readmitted later for excision of the bladder T-tube. The later ureterogram (Fig. 2) showed good function with marked decrease in the hydromegaly on the left side with complete lack of ureal dilation on the right.

This case illustrates that a grossly dilated ureter may improve after implantation.

Experience with this method has shown that it fulfills the essential requirements of lateral anastomosis. It is relatively simple, and both sides may be done at one sitting without interruption of the flow of urine along the ureter during the period of formation of the fistula. The caliber of the fistulous opening is not limited to that of the lumen of the ureter because the longitudinal sutures increase the aperture to an adequate size. We agree with Higgins, Lower, and others that operative intervention in infancy is better than indefinite delay with the resultant development of obstructive uropathy and infection. Sulfathiazole and other chemotherapeutic remedies administered orally and applied locally at the operative site have proved of inestimable value and recent reports of the efficacy of sulfaguanidine and allied agents as intestinal antiseptics indicate that they should prove a valuable supplement to our present preoperative and postoperative care. Our immediate results have been favorable. We hope

that time and experience will demonstrate that the eventual outcome of these cases will be equally satisfactory.

#### CONCLUSIONS

1. A modification of the Higgins technique is presented.
2. The use of 2 crucially placed sutures forms the fistulous opening between the lumen of the ureter and the sigmoid.
3. The resulting stoma is larger than can be obtained by single suture method.
4. There is no apparent loss of the aboral portion of the mucosa.
5. The marked diminution in amount of leakage from the ureteral orifices as soon as the stoma is formed indicates that the fistulas are of adequate size.
6. The resultant absence of swelling makes the time of removal of the bladder optional.

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# PRIMARY ADAMANTINOMA OF THE ULNA

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**P** R I M A R Y adamantinoma of the long bones is an extremely rare entity. Rankin, in 1939, reported the eleventh case of this tumor arising in the tibia. We believe the case of adamantinoma of the ulna recorded here is the first reported instance of the occurrence of this tumor in a long bone other than the tibia.

Adamantinoma or adamantine epithelioma is an infiltrating epithelial tumor, arising from basal cells, which grows in a stroma of fibrous tissue, and reproduces, to a certain extent, the histological characteristics of the primitive tooth bud. In the jaws it is a relatively common tumor. Cases have also been reported of this growth's arising in Rathke's pouch and invading the sphenoid bone.

Theories of origin are interesting, even if of little practical importance. In the jaws and in Rathke's pouch, this tumor probably arises from undifferentiated blocks of basal epithelium which developmentally, normally invaginate the underlying mesenchyma and preosseous tissue. In the long bones, the situation is quite different, and two theories have been advanced to explain the origin of primary adamantinoma in these bones. Fischer assumed the origin of such tumors to be in cell rests. This was based upon his belief that if the tumor cells were implanted at a time later than the fetal period, the potentiality to differentiate into tooth-like structures would not be present, and that pavement epithelium would result.

Ryrie, on the other hand, believes that the tumors arise from basal cells implanted in the deeper structures at the time of an injury. Even if the skin is unbroken, the deeper tissues and skin appendages, such as hair follicles, are torn, and implantation could result. It is interesting to note that in all of the reported cases, the patient recalled a severe blow to the long bone at the site of the ultimate tumor. This theory would seem to be further substantiated by the occurrence of adamantinoma in superficial long bones where the skin is closely apposed to the periosteum and where trauma is frequent. Our own feeling is that the theory of implantation is probably correct, and we suggest that perhaps the environ-

ment, i. e., bone, in which the basal cells are implanted is the determining factor in their differentiation into an adamantine tumor. This would seem to afford the opportunity for some enlightening experimental work in the fields of animal research and tissue culture.

Pathologically, the tumor is a soft, spongy, grey, indistinctly lobulated, vascular growth which occupies the central portion of the shaft of the bone and expands it without breaking through the cortex. Microscopically it is an infiltrating epithelial tumor in a stroma of fibrous tissue.

The epithelial elements are derived from a basal type of cell and may approach either squamous epithelium or enamel epithelium. These cells are arranged in tongue shaped or branching pseudo-acinar processes which contain two distinct cell types, both of epithelial origin. The peripheral cells are of the cuboidal or tall columnar type arranged in one or more layers with their long axes perpendicular to the limiting membrane of the cell group. These are comparable to the ameloblasts of the tooth bud. The central cells are of a cuboidal or transitional type with branching and anastomosing cytoplasmic processes which give a definite stellate appearance. This tissue represents the primitive enamel pulp. Cystic spaces are commonly present in the central area of the aggregations of cells. These arise as a result of degeneration of the stellate cells, so that the spaces are filled with an amorphous coagulum and cellular debris.

The stroma is made up of fibrous tissue of varying degrees of density. Multinucleated giant cells are frequently present and osteoclasts. A few inflammatory cells are sometimes found.

Clinically, adamantinoma of the ulna exhibits the following characteristics: basal cell tumor, it possesses a certain malignancy. Once it is established, it may erode it to a considerable extent, but not have the ability to invade the soft tissue or to metastasize. Cases which require complete removal may involve the bone. Either males or females may be affected. The age incidence is from 22 to 46 years. The growth of the tu-

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Fig. 1

Fig. 1. Roentgenograms of the forearm taken on September 3, 1930, showing the tumor on the shaft of the ulna.



Fig. 2

Fig. 2. Roentgenograms, March 8, 1931, 3 months after partial resection of the ulna and implantation of a bone graft.



Fig. 3

elapsing between discovery of the tumor and surgical treatment in the reported cases has varied from months to 6 years with the oc-



Fig. 3. Photomicrograph, low power showing tissue removed at the first operation in 1930. Cords of epithelial cells, with central cystic spaces in loose stroma of fibrous tissue are seen.  $\times 70$ .

currence of only local extension. All patients give definite history of trauma, usually not of sufficient severity to cause a fracture. Aching pain is often noted, but the usual presenting symptom is the presence of a tumor mass. Tenderness, increased local temperature, edema, and fluctuation may be present in some instances. There are usually no general symptoms such as are observed with malignant bone tumors. In spite of the relatively benign character of adamantinoma, it has a very strong tendency to recur if not completely removed. Treatment therefore, consists in complete surgical excision, resection or amputation. The radiosensitivity of the tumor is low.

Roentgenologically the tumor appears as polycystic, expanding central tumor with sharp outlines and fine trabecular pattern. No periosteal reaction or new bone formation is seen. There are no worm or eroded margins. A fine honeycombed appearance is often seen which is not usually present in bone cysts or giant cell tumors. The differential diagnosis is difficult and the rarity of the tumor makes it even more so.



Fig 4 Roentgenograms, April 10, 1934, show an extensive recurrence of the tumor with complete replacement of the bone graft

case, to our knowledge, has been diagnosed before the pathological examination was made. Even then, many competent, well trained pathologists have encountered difficulties in making the correct diagnosis.

We believe that the following case fulfills the diagnostic criteria of an adamantinoma.

D D (Bone sarcoma registry No. 1819), a white male, 45 years of age, was seen by the late Dr. Hunkin in 1929 because of a complaint of weakness of the right arm of several months' duration, and fleeting, burning pains which radiated up and down the entire arm. The patient had fractured his right arm just above the wrist on two occasions, once in 1902 and again in 1905. The injury in 1905 resulted from a blow received in a football game. The roentgenograms were subsequently destroyed. Several months after the second injury, the patient noted deformity of the right elbow and slight limitation of motion, neither of which had caused any real disability. Aside from



Fig 5 Roentgenograms, September 24, 1934, show further extension of the tumor with destruction of the cortex of the ulna.

these injuries the past history was noncontributory. General physical examination in 1929 was essentially negative. The right arm presented a palpable dislocation of the head of the radius with limitation of supination and a diffuse swelling over the ulnar side of the forearm. Roentgenographic examination showed marked lateral bowing of both the radius and ulna with a dislocation of the head of the radius which appeared to be of long standing (Fig. 1). The proximal end of the ulna was widened and articulated fully with both humeral condyles. The shaft of the ulna was diffusely expanded throughout by a honeycombed rarefying process which extended to within an inch of either end of the ulna. In the distal 3 inches of the expansion the cortex was extremely thin, with large round and smaller foam-like lobulations. The remainder of the involved area had a more dense appearance with definite honeycombed trabeculation. No periosteal reaction was evident.

A resection of the lower portion of the shaft of the ulna with the implantation of an 8 inch tibial graft was performed on September 24, 1929 (Fig. 2). The patient made an uneventful recovery and had good use of his arm but with slight limitation of supination. During the next 4 years he was without pain, discomfort, or other complaint referable to the right arm.

**Pathological report October 4, 1929.** The specimen consisted of a mass of tissue removed from the ulna measuring approximately 4½ by 2 by 1 centimeter. On section, the



Fig. 6. Photomicrograph of a section of the specimen removed on November 26, 1934. The reaction in the tumor removed in 1929. Changes suggestive of squamous cell carcinoma are seen in the lower right hand corner  $\times 70$ .



Fig. 7. Photomicrograph of the tumor removed on November 26, 1934. This shows cellular area with scanty stroma. Peripheral columnar cells and central stellate areas with cystic spaces are evident. Many mitotic figures are present  $\times 70$ .

both of the tissue presented uniform grayish blue, finely granular substance. At one end of the specimen some fine points of calcification were encountered. This presumably was where the bone had been invaded. Sections were taken from all points.

The sections showed an unusual type of tumor. The stroma, as composed of pale staining, fibrillar appearing fibrous connective tissue—not unlike the mesenchyme seen in the embryonic cord. Sometimes irregular elongated spindle shaped nuclei, some dark and slender and others plumper with debately staining stippled chromatin, lay in very delicate eosinophilic fibrillary stroma.

Through this occurred variety of tubes and cords of endothelial cells forming imperfect vascular spaces with single or multiple layers of cells that showed elongated dark nuclei, and more condensed eosinophilic cytoplasm. Some contained what were thought to be red cells. Cords

of similar cells were seen without any lumen, and all gradations existed between the two types. Some of the cells were of distinctly polyhedral outline and of pavement type. Swelling and hyaline degeneration of some of the cords gave an appearance simulating epithelial proliferation. As a matter of fact, cells of the stroma and those forming the cords and vascular spaces seemed to be of the same origin and intermediate forms are prevalent. The method of growth seemed to be the factor determining the exact morphology. Transverse sections of these endothelial cords resembled giant cells.

Cells resembling plasma cells and lymphocytes were present singly and in small groups lying both within and outside endothelial channels. Some of these presented hemoglobin that in the cytoplasm and were believed to represent differentiation of the primitive cells into nucleated red cells and polyblasts. Macrophages were fairly frequent in the endothelial cells. Bits of bone were present in some sections but the tumor did not show evidence of bone invasion (Fig. 3).

The diagnosis was aneurysmal endothelioma.

During March 31 the patient noted recurrence of all the complaints previously mentioned and reoperation was again taken which showed extension of the rarefying process in the ulna and complete replacement of the bone graft by the tumor condition (Fig. 4). One month later he developed tender firm nodules swelling over the middle of the old operative scar. Roentgen therapy resulted in disappearance of the pain and swelling, but these returned after short interval and failed to respond to further roentgen treatment. The patient entered the University of California Hospital on October 1934, completely ready for further relevant history could be obtained. General physical examination revealed no abnormalities except for the right arm. An open wound, inches in length, as present over the ulna. A lump about 1 by 1 by 1 centimeter in size, present in the middle of the scar, was not attached to the skin, but was firmly fixed to the underlying bone. The lump, as tender to palpation but no tenderness or scars were present. The entire arm was diffusely atrophied and segments were wasted. Complete blood count was normal. Lewis Wassermann and Kahn tests were negative. Roentgenograms of the chest were negative. Tuberculin tests were

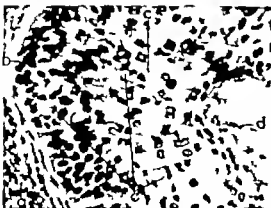


Fig. 8. Photomicrograph high power of portion of the same section as shown in Figure 7. a. Stroma; b. peripheral columnar cells; c. central transitional cells with stellate anastomosing processes; d. cystic spaces; e. cellular debris; no mitotic figures  $\times 1$ .

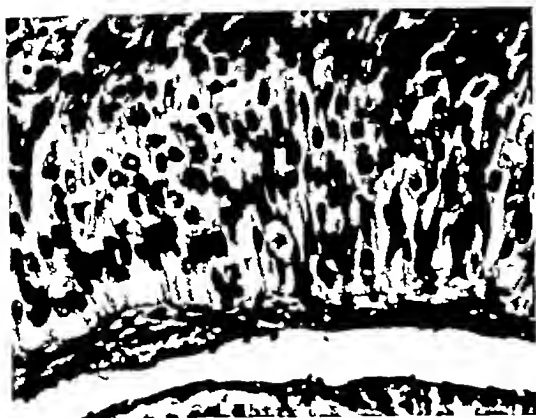


Fig 9 Photomicrograph, high power, of the recurrent tumor (1934) showing the detail of the high columnar cell layer resembling enamel epithelium  $\times 310$

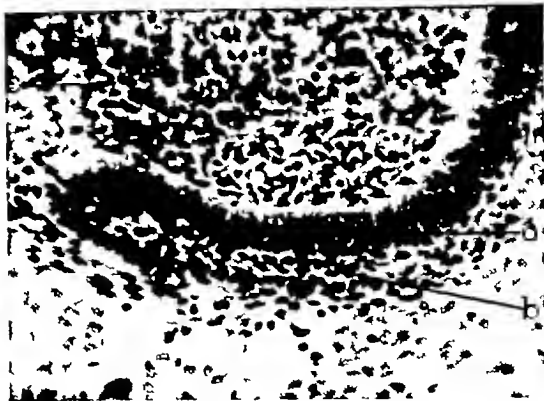


Fig 10 Photomicrograph high power ( $\times 450$ ) of a part of the dental lamina of a 1 day old rat, showing the type of structure reproduced by adamantinoma a, Enamel epithelium, b, "stellate" area, c, primitive mesenchymal tissue

normal balance of calcium and phosphorus metabolism. Blood serum calcium was 10.92 milligrams per 100 cubic centimeters, phosphorus, 3.54 milligrams and phosphatase 8.35 milligrams.

The patient refused further surgery at this time and was discharged from the hospital. During the following month the pain increased greatly in severity and the entire arm became tender. Roentgen examination showed complete absence of bony cortex over the tumor with extension into the soft tissues (Fig 5). The patient submitted to surgery, and at another hospital an attempt was made to resect the ulna and the contained tumor. This could not be cleanly done, and some of the tumor was allowed to remain in the tumor having extended into the muscles and subcutaneous tissues.

*Pathological report, November 27, 1934.* The specimen consisted of a fusiform tumor 11 centimeters long and 5 to 6 centimeters in diameter at its greatest thickness, to the end of which were adherent short segments of bone. The mass was rather firm, rubbery, and had no definite limitations. It appeared to have arisen in the medullary portion of the bone, to have destroyed the cortex for a distance of 11.5 centimeters, and to be extending along the medulla invading and destroying the shaft. On section it was a whitish gray, somewhat fibrous tissue. The central portion presented small light yellow circular areas of degeneration. Small fragments of muscle and tendon were adherent to the tumor and were inseparable therefrom, suggesting the invasion of soft and tendinous tissues. Both segments of the ulna were partially fragmented at the junction with the tumor. The raggedness of the surface of the tumor suggested incomplete removal. At the lower end of the tumor there was a circular silver wire partially embedded in the tumor tissue. Sections from various portions of the tumor mass showed a very cellular structure. Many strands and clumps of elongated and spindle shaped cells were arranged in a somewhat epithelial pattern upon a moderate amount of fibrous stroma. The tumor cells had a clear staining cytoplasm, an elongated or ovoid finely granular nucleus with a small nucleolus. In areas the masses of tumor cells showed small areas of central degeneration. In other areas small circular whorls were formed. At the borders and central portions of some tumor masses the cells were somewhat enlarged but resembled the majority of other cells in pattern.

The diagnosis was "endothelial bone tumor, probably angiosarcoma" (Figs 6, 7, 8, 9).

The wound healed readily, but pain and tenderness returned 2 months later. Amputation was performed through the lower humerus. The patient has been seen at regular intervals since the amputation was performed, and has remained in perfect health with no evidence of recurrence or metastasis for the past 6 years. Unfortunately, the specimen obtained at the time of amputation was destroyed.

This case was submitted to the committee on bone sarcoma of the American College of Surgeons. The opinions submitted ranged from "angioendothelioma" to "typical squamous cell carcinoma." Most of the committee favored metastatic carcinoma. No agreement was reached, however, and the case was listed under the original diagnosis of angiosarcoma.

Upon reviewing the microscopic sections and the patient's case history, we were struck by the long period of survival in spite of the obvious pathological malignancy of the tumor. The first sections (1929) seemed to us to be typical of adamantine epithelioma. The second group of slides (1934) present a very different pattern but contain cells which could be derived only from epithelium and other zones of definite ameloblasts, degenerating stellate cells and many cyst-like spaces.

The sections were re-examined by the pathologists, Drs. Rinehart and Bartlett, who now agree that the neoplasm is an adamantinoma.<sup>1</sup> In view of the fact that a careful search of the literature produced no other case of such a tumor arising in the ulna, it is not surprising that the diagnosis

<sup>1</sup>James Rinehart, Edwin I. Bartlett and Charles L. Connor (deceased) were of invaluable assistance in the pathological examinations. Dr. Judson Sale kindly granted his permission to report this case.





Fig. Roentgenogram illustrating a demineralization of the femur, tibia, and fibula. B, the small bones of the hand and the ulna and radius.

and that with a small daily intake of calcium, it would take considerable time for sufficient re-deposition of calcium to have occurred to show by the x ray.

In addition to thyroidectomy, the fracture itself is treated as indicated by the lesion encountered. Calcium is administered in great quantities daily in an effort to overcome the deficiency which we have found in the osseous structures. As pointed out by Bartle and Haggart, a well balanced diet is important at all times.

#### CASE REPORT

H. J. male aged 36 years, as referred by Dr. M. S. of London, Canada, one of us (L. C. R.) in June, 1930. The chief complaint, as intermittent pain and stiffness in the back, in the region of the first lumbar vertebra. The patient also complained of nervousness, sweating and bulging of the eyes. The family history revealed nothing of significance. The patient had had the ordinary diseases of childhood, measles, scarlet, whooping cough, and chicken pox. His owls had been removed many years ago and the septum had been straightened. He also had had an appendectomy. Father had suffered from "burns" in the neck, back, as opened, but he, as 4 years of age. Thyroidectomy for exophthalmic goiter had been performed elsewhere in 1926.

The patient is married, has two children, aged 5 1/2 years and 6 months. He is happy in his work, drinks very moderately, uses tobacco but not to excess. He has taken Lugol's solution intermittently over a number of years. Venereal infection is denied.

In the spring of 1926 (March) this patient had severe attack of "flu" with high temperature. He became nervous and lost 5 pounds in eight though his appetite was good. His eyes became more prominent. The patient stated that he "shook cold" exceptionally well and wore fewer clothes than most people. He complained more heat of throat and said that his pulse varied from 80 to 100 sometime. His blood pressure was 110/70. The heart was normal except for more arrhythmic extra systoles and tachycardia urine normal basal metabolism as plus 12. A marked tremor as present, the extended

fingers in November 1926, diameter of exophthalmic goiter made.

On December 2, 1926, this patient as subjected to partial thyroidectomy elsewhere. Several months after operation the basal metabolism as minus 30. He was given thyroid extract over a period of 3 months, 1 1/2 times the basal metabolism had returned to normal. At the end of the first postoperative year the metabolic readings were plus 35 and plus 33.

In September 1927, he again consulted his physician. The exophthalmos had become more marked, his pulse as in the neighborhood of 100, his right ankle ached and the blood pressure as 120/70. The electrocardiogram as normal but the output as slightly low metabolic rate as plus 3. The opinion as expressed that there had been recurrence of the hyperthyroidism and return to the surgeon for further treatment as advised.

The patient continued through the intervening years without much change in his clinical condition. He suffered intermittently from frequent mild attack of diarrhea. His bowels are almost in anarchy and the stools as formed. The patient had an aversion to milk and cheese and the calcium intake as, therefore, extremely low.

On January 3, 1928, the patient slipped on ice and fell only a short distance but he suffered immediately from excruciating pain in the back. On admission to the hospital, x-ray examination revealed the presence of fracture of the first lumbar vertebra, plus generalized demineralization of his bones. Several days after his admission to the hospital his pulse increased to 100-120 per minute. The patient became exceedingly nervous. The condition looked like typical hyperthyroid crisis. Because of his demineralization and general bodily disorganization, he as treated by hyperextension on a fracture board. About the 10th day of cast, about March 7, he developed an acute, almost fatal, in bed, which again increased his pulse rate to 120. He was continued to the hospital from January 3, 1928, to March 27, 1928. His activities are greatly restricted. He as furnished a T-joint brace which he used for the next 6 weeks.

Laboratory examinations revealed the blood and urine to be essentially normal. Blood calcium and serum phosphates are within normal limit. Determination of the basal metabolic rate as attempted but proved unsuccessful because of the inability of the patient to breathe free the lung.

During his hospitalization he received calcium phosphate and small doses of Lugol's solution.

About June 1928, following "anorexia" on trials he altered with considerable stiffness and pain in the back for the first time since resumption of partial activity. Roentgenological examination showed marked changes, with collapse of the 5th and 6th thoracic vertebrae. These lesions are not present on the former x-ray film.

On the patient's arrival in Philadelphia, he as admitted to the Presbyterian Hospital. His height as 5 feet 7 inches and his weight 85 pounds. His eyes are very prominent. Von Graefe sign as positive, pulse rate was 144, blood pressure 120/80. The thyroid could not be palpated.

The lungs are normal on superficial inspection, palpation percussion and auscultation. The heart as normal in size, shape and position, and there as no disturbance in rhythm.

The chest and abdomen are both prominent. As was as noted over the apical area, no masses are felt or seen in the abdomen. The patient as rather hairy with heavy beard. The skin as bathed in a brown of the hands as marked and the knee jerk are active. The glands are normal.

At this time the basal metabolic rate was plus 43. Blood cholesterol was 107. Blood count showed red blood cells, 970,000, hemoglobin was 16.24 grams or 104 per cent, white blood cells 3,800, polymorphonuclears 50, lymphocytes 35, monocytes 4, and eosinophiles, 2. The urinalysis was negative except for a trace of albumin. The urine was negative for Bence Jones protein. The urinary calcium for 24 hours was 321 milligrams. Hydrogen ion concentration of blood 7.4. Blood chemistry analysis showed calcium 10.5, phosphorus 2.1, phosphatase 0.25. Second examination showed calcium 10, phosphorus, 2.1, phosphatase 5.95, protein of the blood 7, albumin 5.8, globulin, 2. The stools were semiliquid large in amount with no abnormal constituents. Capillary permeability and bleeding time were normal.

Comprehensive roentgen studies of the osseous system showed generalized demineralization which was considered most likely to be due to hyperthyroidism. Paget's disease and malignancy appeared to be excluded, multiple myeloma was practically excluded.

A small nodule was encountered on the left side of the neck on June 20, 1940. It was explored by one of us (F. A. B.) and was found not to be a parathyroid gland.

The clinical diagnosis in this case was hyperthyroidism with marked decalcification, the patient exhibiting both traumatic and spontaneous fractures. Hyperparathyroidism, multiple myeloma and malignancy were considered, but were considered to be unlikely. It was thought perhaps that decalcification was the result of three factors: (1) prolonged continuous hyperthyroidism, (2) continuous but mild diarrhea, (3) aversion to foods rich in calcium resulting in meager calcium intake.

The roentgenograms suggested the possibility of multiple myelomas. To rule this out the patient was sent home advised to remain at rest, take a diet rich in calcium and phosphorus. Calcium gluconate was administered parenterally and by mouth. Cod liver oil and viosterol were also employed. After 2 months on this regimen no evidence of improvement was apparent. The patient returned to Philadelphia laboratory studies were repeated with results that were practically identical. The basal metabolic rate was plus 39. Surgery was advised and after adequate preoperative preparation an exploratory operation was performed by one of us (F. A. B.) on September 11, 1940. After the ribbon muscles were retracted a mass could be palpated in back of the trachea on the right which upon exploration proved to be a large adenomatous right lobe. This was removed. A small pyramidal lobe was located high in the neck and was excised. On the left another portion of adenomatous thyroid was removed subinternally and behind the trachea.

The specimen consisted of three pieces of thyroid tissue, 5 by 3.5 by 3 and 2 by 2 by 1 centimeter respectively, and weighing 50 grams. The lobes were well encapsulated, and they consisted of moist, glistening, brownish yellow, granular lobulated tissue in which were hard white calcified nodules, small cystic spaces, and soft yellowish pink nodules.

Microscopic examination of the thyroid tissue revealed marked variation in shape and size of acini. The lining cells are of the low cuboidal and occasionally low columnar type, rarely being thrown up into a spur. The colloid has not completely been restored and much of it assumes a granular appearance. There are focal accumulations of lymphocytes and in the interspaces not showing follicle formation. Several of the sections show a well encapsulated mass bordered by compressed and atrophic thyroid tissue. Portions of this mass display fairly typical thyroid tissue which presents the changes described before. Other portions have a collagenous stroma supporting tiny



Fig. 2. Roentgenogram of the spine illustrating demineralization and traumatic fracture of the first lumbar vertebra.

acini lined by small hyperchromatic cells resembling the fetal type. There is no evidence of malignant change within the adenoma.

The diagnosis was toxic nodular goiter with incomplete involution.

Following operation the patient made an uninterrupted recovery. At the end of 2 weeks the symptoms of hyperthyroidism had almost completely disappeared. The basal metabolic rate had decreased to plus 13, the pain in the back had diminished considerably, and the patient walked about the room with relative comfort. Shortly after the patient returned home for the first time in many months he was able to go to the table for meals, go up and down stairs and get out for short walks without any discomfort or distress.

Six months following operation his basal metabolic rate had fallen to minus 8. He was placed on 1 grain of desiccated thyroid for a few weeks. Ten months after operation, the follow-up visit showed the patient had been completely relieved of the symptoms of thyrotoxicosis. His activity had returned to a normal routine. The brace was discarded 7 months after operation, and all symptoms which were relative to his back had disappeared. The exophthalmos had diminished and he had gained 17 pounds in weight.

There have been many x-ray studies subsequent to operation, which revealed that the fractures in the vertebrae had united and there was a very slight increase in the calcium in the vertebral bodies. The generalized demineralization was still present with very slight apparent improvement in calcium content.

Fourteen months after operation the symptomatic cure was complete. The patient, formerly a helpless invalid, had been restored to perfect health and was back at work on a full time basis. The recalcification of the bones, however, in this individual as in other cases reported in the literature, was tardy and unimpressive, as revealed by the x-ray. More time is needed before a final statement relative to remineralization can be made.

X-ray examination of the spine in April, 1942, revealed a moderately improved mineral content of the bone structure since December, 1940.

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# INTERNAL WIRE FIXATION OF JAW FRACTURES

## Second Report, with Note on External Bar Fixation

JAMES BARRETT BROWN, M D , F A C S , and FRANK McDOWELL, M D ,  
St Louis, Missouri

SINCE the preliminary report,<sup>1</sup> this method has continued to be of major service in the fixation of difficult jaw fractures. The necessity for wide open reductions has almost been eliminated, and complicated dental appliances are avoided.

The patients appreciate being able to open and close their mouths throughout the healing period (Fig 1), and the added cleanliness is an advantage in the care of any lacerations inside. It has been easier to maintain the airway in patients with much upper neck swelling from hemorrhage or infection, and tracheotomy has been avoided in one instance. Its use might be desirable in military personnel who are apt to be seasick, and in patients who require a general anesthetic for other injuries. However, patients with associated condyle fractures should have additional interdental fixation to the upper jaw or some method of holding the chin forward in proper occlusion. This seems to be the simplest and best treatment for this fracture, although many recommenda-

tions have been made, from immediate open operation to doing nothing.

*Sequelae and complications* have been minimal and there has been no extensive osteomyelitis. There have been occasional late small abscesses beneath the fracture sites, as may occur with any other method of treatment. A few instances of small localized areas of osteomyelitis occurred on the undersurface of symphysis fractures, with the late extrusion of a few small bone chips. It is possible that these resulted from the cross-fracturing of the inferior cortex, either when the wire was drilled in or later from chewing, as they have all occurred in instances in which the wire was put in so low that only the cortex was left below it. This complication has not developed in symphysis fractures in which the wire was drilled through higher in the bone, and as the nerve supply to the teeth is relatively high in front of the mental foramina, it is suggested that a sufficiently strong bridge of bone should be left beneath the wire in this location.

The skin holes have healed without noticeable marks in almost all instances, though it may be best to push the fat pad of the chin up out of the way when wires are put directly through this

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<sup>1</sup>Internal wire fixation for fractures of the jaw, preliminary report Surg Gyn Obst 1942 74 227



Fig 1. Fixation of double fracture with two internal wires and an anterior dental arch. Angle fracture was so



far back that the wire was drilled vertically through it up into the ramus. Patient could take soft foods from the first

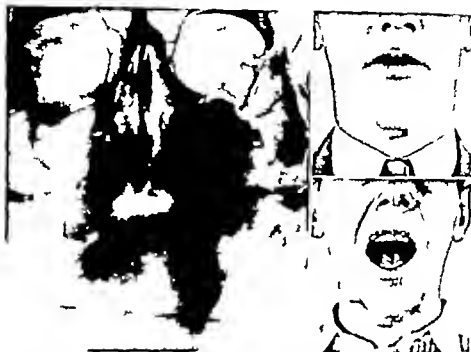


Fig. 2. Displaced symphyseal fracture and depressed orbital floor. Open-mouth treatment of lower jaw. Its internal arch and anterior incisor arch. The orbital floor is

elevated through the antrum and held with a padlock pack. The beaded skin holes are scarcely visible upon right illustration.

region (Fig. 2). In instances of nonunion has occurred, even though several of the patients were first seen late after infection had developed. This brings up the interesting possibility that the drilling across the fracture site may be osteogenesis.

Titanium and other alloys have been considered, but the stainless steel wires have proved to be satisfactory. They should be of the same material throughout and polished rather than coated. The smallest size that will produce the necessary rigidity in each instance should be used. Wires of .035 inch or .045 inch diameter are generally used, though ones up to .08 inch have been employed. A three-sided point seems easier to start in the bone than the usual spade point, and the sides of the point should have a long bevel. This was recommended by Dr. C. H. Crego.

Reaction around the wires has been so slight that many patients have neglected to keep even small dressings over the ends, though this is advised. Even after 6 weeks they often have to be rotated many times and considerable traction used for their extraction. Threaded wires have to be unscrewed throughout their length for removal

and most of the removed wires have shown evidence of corrosion. Because of the persistent tightness of the plain wires, the threaded ones are seldom used, though they probably give a slightly more rigid fixation.

#### OPERATION

The best possible occlusion should be maintained during the insertion of the wire. One person usually holds the fragments in place with his hand while another one drills the wire through. When teeth are present it may be easier for the one holding if a dental arch is put on first. This is a simple anterior wire arch of No. 26 stainless steel wire. One wire is looped around each back tooth on each side and the ends twisted together for 2 to 3 inches. The two wires are then anchored together in front with a few turns and the arch is held firmly with finer wires, No. 28, around (and between) teeth. This arch gives a second plane of fixation and helps hold any block detachments of the teeth and alveolus. It has to be omitted, of course, when there are not sufficient teeth.

The drill operator should be careful not to contaminate his gloves or the wire with mouth secre-



Fig 3 a, b, Displaced fractures at mental foramen and opposite angle with main fragment hanging down c, d,

Fixation with 2 internal wires and an arch bar Patient able to open and close mouth throughout treatment

tions and the skin should be prepared again just before the point is inserted. An ordinary motor-driven bone saw, with a chuck to accommodate the wire, is most often used. Dental engines do not seem to have enough power. If the fragments can be held in a sufficiently stable manner, an ordinary carpenter's hand drill can be used at times. The rotary speed of the wire should be enough for easy penetration but not so fast as to possibly produce heat necrosis of the bone. In this connection, it is thought that a too slow forward speed or a dull point may produce an excessive amount

of heat in one area. Threaded wires must be put in at a low speed as they definitely catch and take hold in the cortex and go in so fast as to be out of control at a high speed.

A nick is made in the skin and a small area of periosteum is denuded where the wire is to be started. The most difficult place to get started seems to be on the back of the ramus when drilling forward through an angle fracture. To do this, the head is usually rotated to the opposite side and the lobe of the ear held up out of the way. The wire is cut down to the minimal necessary length



Fig 4 Fractures in front of both angles in a man with very few teeth. Long posterior fragment on right side edentulous and one on left side contains just one tooth

Interdental wires also were left on a few days. Patient returned to work within a period of 10 days. Solid union obtained.



Fig. 1. Displaced symphysis fracture and depressed orbital floor. Open mouth treatment of lower jaw with internal wire and anterior bite arch. The orbital floor is

elevated through the nostrum and held with an holders pack. The healed skin holes are scarcely visible, upper right illustration.

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and most of the removed wires have shown evidence of corrosion. Because of the persistent tightness of the plain wires, the threaded ones are seldom used, though they probably give a slightly more rigid fixation.

Gold, titanium and other alloys have been considered, but the stainless steel wires have continued to be satisfactory. They should be of the same material throughout and polished, rather than coated. The smallest size that will produce the necessary rigidity in each instance should be used. Wires of .015 inch or .017 inch diameter are generally used, though ones .018 inch have been employed. A three-sided point seems easier to start in the bone than the usual spade point and the sides of the point should have a long bevel. This was recommended by Dr. C. H. Crego.

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Reaction around the wires has been so slight that many patients have neglected to keep even a small dressing over the ends, though this is advised. Even after 6 weeks, they often have to be rotated many times and considerable traction used for their extraction. Threaded wires have to be unscrewed throughout their length for removal,

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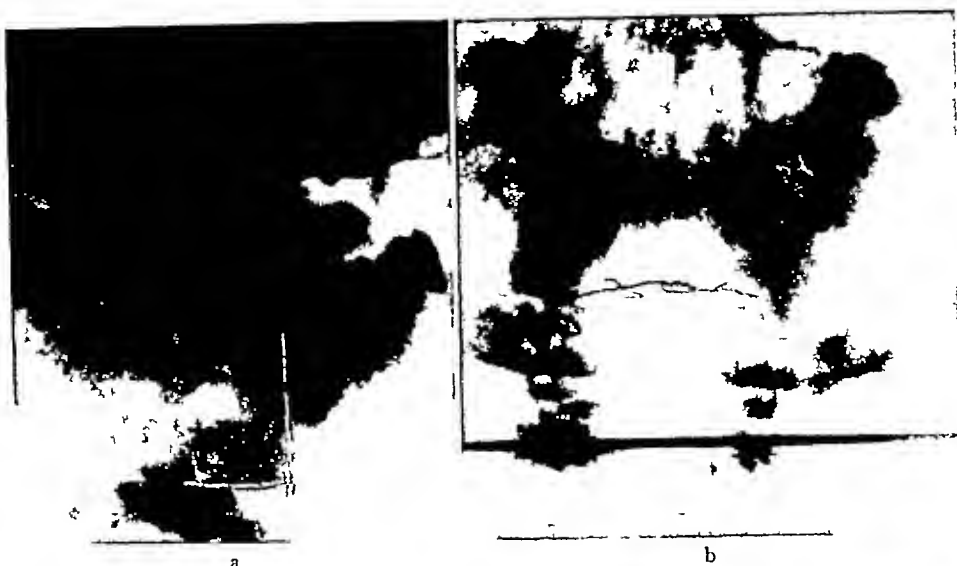


Fig 6 Severe injury with basal skull fracture, broken condyle and symphysis, and depressed fractures of both orbital floors. Treatment delayed 1 week until patient was rational and not vomiting. a and b, Fixation used, interstitial wires being added because of condyle fracture. Both orbital floors elevated through antrum and held with iodoform packs beneath them. c, After removal of packs and interstitial wires.



on the teeth) in symphysis fractures to prevent "rocker" motion (Fig 6). It has also been used for certain upper jaw fractures (Fig 7) and (with larger pins) as a means of holding the mouth open for skin grafting inside (Fig 8).

In fractures seen late with large abscesses present, the latter have been drained and the fixation has been done a few days later, an effort being made to avoid going through infected soft tissues in so far as possible.

#### EXTERNAL BAR FIXATION

*Severe, shattering injuries* may still tax the ingenuity of the operator if the loss of fragments and continuity and the necessity for late bone grafting are to be avoided. They may require combinations of interstitial wiring, arch bars, internal wire fixation, and external bars applied with wood screws.

The latter method consists of putting a wood screw through the outside into each of the larger





Fig. 3 a, Bilateral fracture in totally edentulous patient as able to put in upper and lower dental plates and eat soft foods after the first week, though the lower plate was painful if left in continuously. Returned to work

in 4 weeks. b Angle and mental foramen fractures in almost edentulous patient. Open reduction aided and fixation of an almost edentulous patient in an interim maxilla as solid enough to hold without any co-operation

to prevent any lateral whip when it is rotating and the point is inserted against bare bone. The drill operator may then hold the wire near the tip with a small piece of greased gauze or any other type of bearing to steady it. The wire may be drilled on through the cortex and skin in front, or if a good length of jaw is engaged, the point may be just left in the bone (Fig. 3). In angle fractures which are so far back that they tend to be in the ramus, it may be better to start the wire on the lower border of the jaw and drill vertically upward into the ramus, staying outside of the third molar (Fig. 4). In the case of long posterior fragments, it may be less difficult to start the wire just in front and below the mental foramen and then to drill backward through the fracture (Fig. 4).

The work is most often done under maximum deep-block anesthesia with or without a supplementary basal anesthetic. Even with the lower jaw completely anesthetized, a patient with teeth can usually tell when his normal occlusion is restored, and this may be of help at times.

Ordinary interdental wiring is still recommended for fixation of simple fractures when enough teeth are present. The internal fixation is used when there are insufficient teeth or for more severe fractures to hold complicated appliances and wide open reductions, or when it is desirable to leave the mouth open. It is probably the simplest method of fixation of displaced edentulous jaws or fragments (Fig. 5) including the posterior fragment of angle fractures. A further use is as a second plane of fixation (in addition to an arch bar

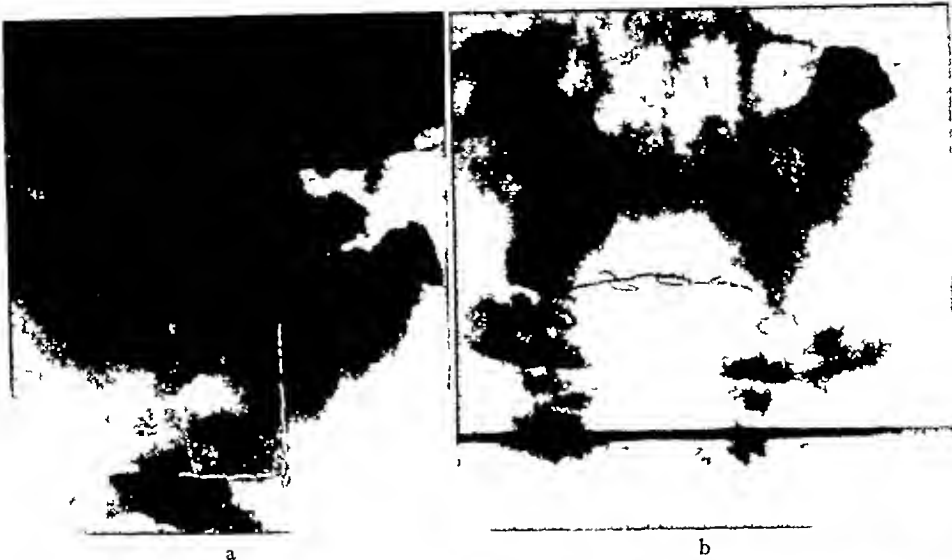


Fig 6 Severe injury with basal skull fracture, broken condyle and symphysis, and depressed fractures of both orbital floors. Treatment delayed 1 week until patient was rational and not vomiting. a and b, Fixation used, interdental wires being added because of condyle fracture. Both orbital floors elevated through antrum and held with iodoform packs beneath them. c, After removal of packs and interdental wires.



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Fig. 7. Severe facial injury with partial obstruction of airway from swelling in upper neck, necessitating operation in semisitting position. The entire left upper jaw was hanging down. In the mouth, before separated in the midline of the palate and transversely through the middle of the

antrum. Symphyseal arch widely separated and submental region full of blood. a. Method used for fixation of bone. Soft tissues of palate were sutured. b. Patient, as in hospital 8 days, began to eat soft foods in few days and returned to work in 3 weeks. Tracheotomy promptly avoided.



Fig. 8. Old burn with inside of mouth almost entirely filled with dense scar. Floor of mouth and tongue grow solidly to palate so no opening of jaw as possible. Mass



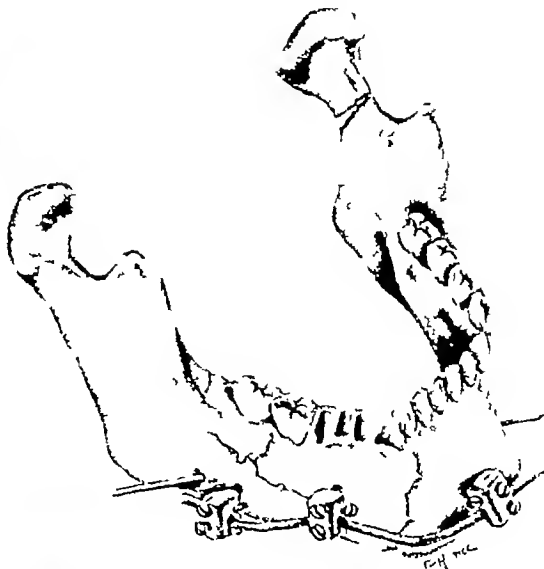
bone fragments, and then attaching 11 of the screws to a rigid external curved metal bar (Fig. 10). They can be attached to the bar by means of

of scar excised from mouth to permit opening, then held open to permit later skin grafting by means of 12 and 14 inch) Steinmann pins and wooden blocks

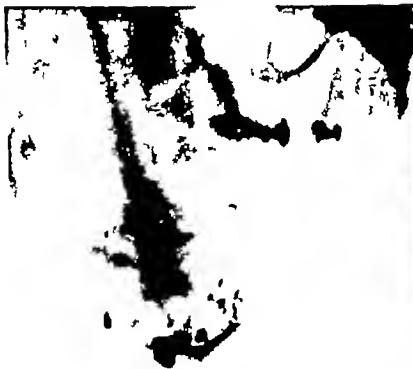
separate lugs, or by means of compressible slits which can be soldered to each of the screws beforehand. A small nick is made in the skin and a drill



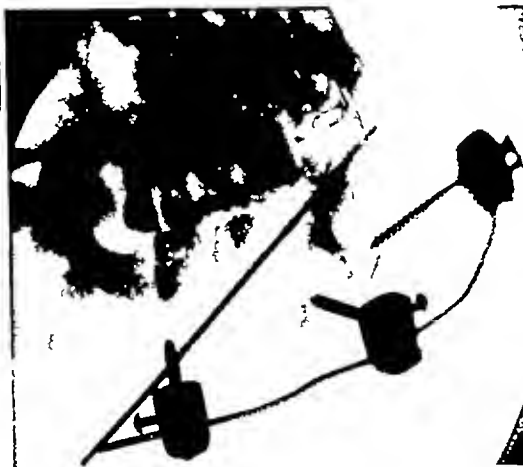
a



b



c



d

Fig 9 Shattering jaw injury with partial collapse of airway Arrived sitting in an ambulance with accompanying physician holding jaw forward when necessary Large fragment displaced down into soft tissues of the neck All major fragments saved, reduced, and immobilized with external bar and internal wire A few interdental wires were also placed where teeth were present, because of condyle fracture Solid union with good occlusion obtained Late bone grafting avoided Lugs designed by Dr James A Brown

hole into the cortex to aid in starting the screws, but they then take hold quite firmly with just one or two turns It is probably most advantageous to put two screws in each of the major fragments in front and in back of the shattered area, or to use an additional internal wire, in order to secure rigid fixation

The bar acts as a space retainer, as well as a means of fixation, and it is, therefore, possible to leave some questionable fragments in the shattered area until their viability is finally determined In one such case, a fairly large separate fragment had been driven down into the soft tissues of the neck, but was replaced and united



Fig. 1. Open mouth treatment of multiple fractures (4) in edentulous jaw with external bar fixation. Four good screws directly in fragment. Apparatus removed in 5 weeks, union solid. Lugs designed by Dr. James A. Brown and used on patient of Dr. Louis T. Brown at St. Louis City Hospital.

firmly with the fragments on either side (Fig. 9). In such instances, any soft tissue or periosteal attachments to the fragment should be most carefully preserved. Due to its simplicity the external metal bar may be capable of use further forward in warlike injuries than more complicated methods.

These lugs with set screws for the bone screw and for the external arch and the screws with compressible slots to hold the external bar have been designed by Dr. James A. Brown, and more detailed account is to be published.

The internal wire fixation does not require the persistent and close after-care necessary with intricate dental splints, elastic traction, or plaster caps and external traction. In most instances, only 1 or 2 days hospitalization is sufficient and some patients have returned to work after the first week, reporting for inspection each week or so, or if any unusual symptoms develop. This might be of some value in the postoperative care of mass civilian or military casualties when hospital and surgical facilities might be limited.

# TOTAL GASTRECTOMY

## Technical Considerations

CHARLES BRUCE MORTON, II, M D, Charlottesville, Virginia

**I**N a previous report I recorded the cases of four patients subjected to total gastrectomy (8). The technique employed in the last three was so satisfactory that it seemed worth describing in detail and it forms the basis of this report. Concerning technique it is of interest that the first total gastrectomy recorded was done by Conner in 1884. It resulted fatally for the patient. Schlatter in 1897 removed the entire stomach and his patient survived. As recently as 1933, Roeder found only 88 published instances of the operation. During the past 10 years the operation has been performed much more frequently than before but it is still not commonplace. The indications for total gastrectomy, including suggested liberalization of them, have been discussed in previous communications (8,9) and hence will not be repeated here.

### PREOPERATIVE TREATMENT

It is believed that the treatment the patient receives during the few days preceding operation is one of the most important factors of safety for the operation itself. The first effort is aimed at accurately determining the patient's general physiological status. The next effort is directed toward correction of any abnormality that may have been found. Dehydration, anemia, plasma chloride or protein deficiency, nitrogen retention, cardiovascular renal dysfunction or other serious physiological abnormalities if existent are combated by appropriate measures. Intravenous administration of solutions of sodium chloride or glucose and of plasma or whole blood is frequently necessary.

This accomplished, the gastrointestinal tract itself is prepared, usually for at least 2 days. The patient with gastric stasis is allowed nothing by mouth, and fluid balance is maintained by solutions of glucose and sodium chloride administered intravenously. Patients without gastric stasis are permitted clear strained liquids by mouth, but in addition receive one intravenous injection of 1000 to 1500 cubic centimeters of glucose or sodium chloride solution each day. In all patients a gastric lavage is administered each night, and

preparations are made for at least one or two transfusions of blood (500 c.c. each). During the night before operation some of the barbiturates are employed for sedation, and nothing by mouth is allowed.

On the morning of operation, a small caliber stomach tube is introduced through the nose, passed into the stomach, and attached to a negative pressure apparatus (Fig. 1, insert). It is desirable that this be done at least an hour before the operation. With proper sedation the patient arrives in the operating room in a distinctly drowsy state.

### ANESTHESIA

It is believed that spinal anesthesia is of the utmost importance in facilitating the operation. Pontocain, 20 milligrams dissolved in 4 cubic centimeters of a mixture of equal parts spinal fluid and 5 per cent solution of glucose, injected in the subarachnoid space between the last dorsal and first lumbar vertebrae, has proved ideal. Immediately after the drug is injected the table is tilted, head down, at an angle of about 10 to 15 degrees, until the level of anesthesia, determined by pricking the skin, reaches to just below the nipples. This occurs usually in from 3 to 5 minutes, after which the table is levelled and the anesthesia remains fixed for usually as long as 3 or 4 hours. Continuous spinal anesthesia as described by Lemmon and others might be equally or even more satisfactory but was not tried in the cases comprising this report.

### OPERATION

The technique of the operation was evolved by the study and adaptation of various techniques employed in cases reported by Allen, Lahey, Graham, Walters, and others and by lessons learned through previous experience with subtotal gastrectomy and total gastrectomy. The smooth course of the patients postoperatively indicates that the technique is sound.

In the cases of this report, incision in the middle of the abdomen from the xiphoid to the umbilicus was employed with entire satisfaction and provided excellent exposure. Thorough exploration to determine the extent of gastric invasion and the absence of inoperable extension

From the Division of Clinical Surgery and Gynecology, University of Virginia.

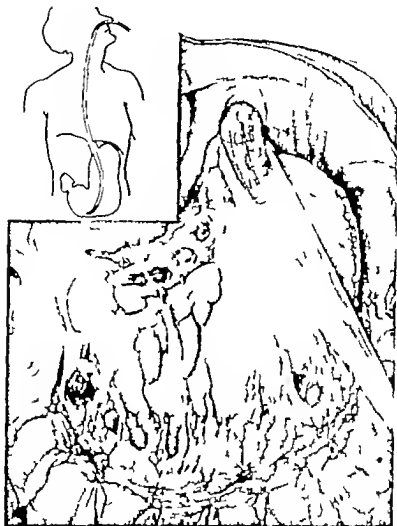


Fig. Exposure of the lower part of the esophagus and the first portion of the duodenum together with complete mobilization of the rotary stomach and its contiguous tissues. Lowest call attention to stomach tube passed orally.

or meta tastes must be carefully carried out. Provided total gastrectomy seems to offer complete eradication of the tumor, the operation proceed. During its course the patient condition is watched carefully and fluids and blood as indicated are introduced intravenously.

With traction on the stomach the peritoneum on each side of the cardiac orifice is incised and a finger is gently worked around to encircle the esophagus and to permit tape to be passed around the lower end of the esophagus. In some instances, severance of the peritoneal attachment

of the left lobe of the liver to the diaphragm facilitates the exposure. Next the first portion of the duodenum is freed by sharp dissection. Vessels are clamped, sectioned, and ligated with fine silk first in the gastrocolic and then in the gastrophrenic omentum so that they may be entirely removed with the stomach. The levo-gastric vessels are sectioned and the spleen to insure removal of lymph channels and glands found among them. The left gastric vessels are sectioned as close to the celiac axis as possible so that lymphatic tissue in that region may be



Fig 2 The duodenum has been sectioned the distal end closed by suture. The stomach has been reflected upward, thus exposing the posterior aspect of the esophagus. Disposition of the afferent and efferent limbs after suture of the jejunum to the pillars of the diaphragm posteriorly. Note the small denuded area on the afferent loop representing the point of division of the ligament of Treitz.

radically removed. The stomach now lies entirely free and traction on it will usually pull down a generous part of the lower end of the esophagus and provide surprisingly good exposure (Fig 1).

A slit is made in the transverse mesocolon, extending down to the ligament of Treitz which is severed so that an appropriate length of the first portion of the jejunum may be brought up for later anastomosis with the esophagus. The slit in the mesocolon is then partly closed by suture with fine silk to the mesentery of the jejunum passing through it and the efferent loop of the jejunum is loosely sutured obliquely through the anterior part of the slit in the mesocolon,

thereby closing the remainder of the opening (Fig 2).

In addition to the usual towels placed to cover the skin margins, the wound edges are covered by infolded laparotomy pads and the intraperitoneal field of operation is carefully isolated in the same manner. The first portion of the duodenum is severed between clamps 2 or 3 centimeters distal to the pylorus, and the distal end is closed by inverting sutures of chromicized catgut and is buried in the head of the pancreas. The stomach is folded upward on the chest and a row of sutures of chromicized catgut is employed to suture the posterior aspect of the peak of the jejunal loop





Fig. 3

Fig. 3 Traction sutures increase width of esophagus as the outer posterior row of suture is placed to exit the jejunum and the posterior all of the esophagus.



Fig. 4

Fig. 4 The inner posterior row of suture is progressing to exit the proximal aspects of the jejunum and the posterior all of the esophagus.



Fig. 5

Fig. 5 The inner anterior row of suture is progressing to exit the proximal aspects of the jejunum and the anterior all of the esophagus. Dotted line indicates the last part of the anterior esophageal all which is to be sectioned and sutured, thus completing the inner anterior row of suture.

the pillars of the diaphragm behind the esophagus with the efferent loop directed toward the patient's right side (Fig. 6). Allis forceps or traction sutures placed on each side of the cardiac orifice are employed to attain the maximum width of esophagus so that the outside row of chromicized catgut sutures for the end-to-side esophagojejunal anastomosis may be placed posteriorly (Fig. 7). Next a small opening is made in both esophagus and jejunum, and a suture of chromicized catgut with a small curved, swaged needle on each end is placed to begin the pos-



Fig. 6 The outer anterior row of suture completing esophagojejunal end to side anastomosis.



Fig. 7 The final step, exit of the jejunum to the pillars of the diaphragm. Jejunum has completed the operation.

terior part of the inner suture line. At this point in the operation the tube in the esophagus is grasped, withdrawn from the stomach and introduced into the efferent loop of jejunum so that the multiple large perforations in the tube remain at the region of the anastomosis. The other end of the tube, attached to a negative pressure pump, keeps the field of anastomosis dry and clean. As the sutures of the inner row are placed, the openings in both the esophagus and the jejunum are enlarged (Fig 4) until the entire posterior row is completed. Traction on the still attached stomach keeps the esophagus well down so that suture, while a little tedious, is not difficult. As the anterior suture progresses by the Connell method from each side toward the center, the anterior wall of the esophagus is more nearly severed (Fig 5) and is finally completely severed as the last suture is placed and the knot tied, completing the anterior part of the inner suture line. The end of the suture employed for the posterior part of the outer suture line is then used to complete the anterior part of the outer suture line (Fig 6). Finally the end of the suture first used to suture the posterior side of the jejunal loop to the pillars of the diaphragm is continued to suture the anterior side of the jejunal loop to the diaphragm in front of the esophagus (Fig 7). The suture of the jejunal loop to the diaphragm all around the anastomosis itself relieves the anastomosis of all tension and is an essential feature of the technique.

The anastomosis and the disposition of the jejunum as described leaves the shortest kind of afferent loop, all above the transverse mesocolon, and consequently an equally short efferent loop passing through the mesocolon. By this method there is no logical place for, nor need of, an enterostomy. A jejunostomy tube may be placed lower down in the jejunum for feeding if desired but it was not used in any of the patients operated upon by this technique.

The incision is closed without drainage of the peritoneum though small soft rubber drains are placed in the subcutaneous tissue between the

stay sutures. These are removed with the skin sutures in from 5 to 7 days.

#### POSTOPERATIVE TREATMENT

Postoperative care of the patients is most important. Constantly maintained negative pressure in the tube placed at operation to continually aspirate all fluid material at the site of anastomosis, adequate sedation, use of fluids intravenously, parenteral administration of vitamins, and transfusions of blood are the essential measures. The tube may be removed in from 7 to 10 days, and the next day sips of water by mouth are allowed. During the next 2 or 3 days, the patient fairly rapidly increases the intake of liquid and then soft foods and in about 2 weeks from the time of operation will tolerate a regular five meal type of diet readily. The meals must remain small and frequent for a period of several weeks but soon both the afferent and efferent jejunal loops dilate to form a stomach-like reservoir so that regular and normal size meals are well tolerated. Any tendency toward anemia should be treated with liver extract and vitamins probably should be recommended for a time. Follow-up examination of all patients operated upon by the technique described had demonstrated freedom from digestive symptoms, little or no anemia, excellent general health, a sense of well-being and economic rehabilitation.

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## AMYLOID GOITER

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THE occurrence of amyloid deposits in organs other than the liver, kidney, spleen and adrenal glands is not commonly observed; there is, however, a number of reports of deposits in such unusual places as the heart, lungs, muscles, intestines, lymph glands, and, in fact, almost every organ of the body, including the brain. One of the most infrequently involved organs is the thyroid gland, and it is the purpose of this paper to review the literature and to report 2 cases of amyloid in filtration of the thyroid gland.

A search of the literature discloses 56 cases; the cases reported herewith bring the total to 58.

Amyloid deposits in the thyroid gland occurred as a part of the secondary type of amyloidosis in 40 cases, Peters, Schilder, Inland, Wegelin, Bannick, Berkman and Beaver, Theodore.

In 3 cases a clinical diagnosis of generalized amyloidosis was made or suspected, and amyloid was found in the thyroid removed surgically; from 2 of these (von Eiseleberg and Toland and Kroger) while amyloid in the thyroid was suspected clinically but not proved in the third, Bannick ( ). Thus in 43 cases the lesions were definitely or probably associated with generalized amyloidosis.

The primary disease was pulmonary tuberculosis with or without cavitation or involvement of other organs in 13 cases (von Eiseleberg, Schilder, Inland, Hunter and Seabrook, Toland and Kroger).

Purulent bronchitis and bronchiectasis were present in 3 cases (Wegelin, Oberling, Theodore).

In 2 instances amyloid was confined to the thyroid gland (Schilder and Oberling).

Neoplastic processes were present in 3 cases, carcinoma or sarcoma in 2 (von Burk) metastatic lymphosarcoma in 1 (von Jacquet) and a carcinoma, the third (Stoffel).

Syphilis and tuberculous were probably associated in 1 case (von Eiseleberg).

In 4 cases the amyloid in the thyroid was associated with the primary type of amyloidosis (Lohmisch, Strauss).

In 13 cases the associated disease was not reported or not found (Peters, Montach, Wegelin, Osgood, Bannick, Berkman, and Beaver and Bannick).

Enlargement of the thyroid, true amyloid goiter was present in 35 cases. In 5 of these the goiter was removed surgically. One patient died 3 days after operation (Oberling). 3 recovered from pressure symptoms (Montach, Hunter and Seabrook, Toland and Kroger). One patient, as confirmed after operation because of active pulmonary tuberculosis from which he eventually died (Toland and Kroger, personal communication). One patient developed parathyroid tetany after operation (von Eiseleberg).

### CASE REPORTS

CASE 1. A white male aged 60 years, admitted to the University of Kansas Hospital, on the service of Dr. R. H. M. for complaining of greater breathlessness, coughing, and pain over the shoulders. He had been well until 5 years prior to admission when chronic cough and gradually increasing weakness developed. Several years ago severe attack of influenza, as followed by stagnation of his cough. He was treated for pulmonary tuberculosis 1 year, tuberculosis 5 or 6 years ago and retained some improved. 7 or 8 years ago he noticed tumor in the anterior cervical region, which gradually increased in size and as associated with nervousness. For 3 weeks prior to admission he was confined to bed because of breathlessness, edema, nausea, vomiting, and severe epigastric pain.

Physical examination showed an emaciated patient with poorly complexion. The anterior cervical lymph nodes were enlarged, and there was a tumor in the region of the thyroid, which was great firm and nodular the size of grapefruit. The pulse rate was 100 per minute and regular. The blood pressure was 80 systolic and 44 diastolic. Thoracic expansion was limited bilaterally; lower crepitation of lungs heard over both apices.

X-ray examination revealed chronic fibrous pulmonary tuberculosis on the right, high diaphragm, and fluid on the left. Laboratory studies showed hemoglobin 55 per cent, nonprotein nitrogen, 100, creatinine, 5.4, albumin, plasma urine specific gravity, 1.021. Basal metabolic rate was plus 15 per cent in single determination.

The clinical diagnosis was pulmonary tuberculosis, chronic toxic colloid goiter.

The patient, condition, was not considered such as to permit any surgical procedure, chiefly because of breathlessness that was not ameliorated by bed rest, supportive treatment as given, but the patient became gradually worse and died on the 5th hospital day.

Postmortem examination was done and revealed the following: the body showed considerable emaciation and there was a tumor in the region of the thyroid 7.5 cm. anterior in transverse diameter projecting forward 3 cm. superiorly.

The right thorax contained 100 cubic centimeters of clear fluid. A few fibrous adhesions were present between the right lung and the pericardium, the right lung was moderately expanded, extending over the mediastine to the left mediocardiac line. The left lung was much reduced in size.

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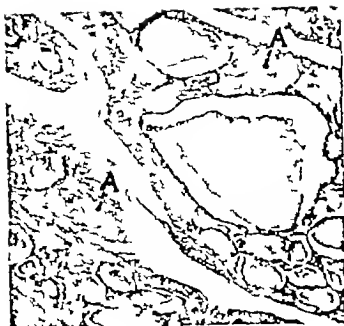


Fig 1



Fig 2



Fig 3



Fig 4



Fig 5



Fig 6

Fig 1 Case 1 Section of the thyroid showing retraction of colloid and follicles in various stages of atrophy. The thick septa *A* are lamina of amyloid.  $\times 55$

Fig 2 Case 1 Section of thyroid showing almost complete displacement of follicles by lamina of amyloid in the stroma. An atrophic follicle can be recognized at *A*. Note the fat tissue infiltration and scattered mononuclear leukocytes.  $\times 55$

Fig 3 Case 1 Focal inflammatory lesion consisting of a patch of fibrous tissue infiltrated with mononuclear cells and a few giant cells.  $\times 55$

Fig 4 Case 1 High power of the area outlined in Figure 3. Note the multinucleated giant cells at *B* and *C*. These did not contain amyloid. The lesion is obviously not a tubercle and apparently represents a reaction to the amyloid present.  $\times 55$

Fig 5 Case 2 Section of thyroid showing colloid filled follicles separated by lamina of amyloid at *A*.  $\times 55$

Fig 6 Case 2 Section of the thyroid showing extensive infiltration of the stroma with amyloid at *A*. Note at *B* the atrophic follicles, some of which contain irregular shrunken masses of colloid.  $\times 85$

and was completely adherent to the chest wall except posteriorly where a thick walled empyema cavity containing 100 cubic centimeters of pus was found. The mediastinum was displaced to the left. There was bronchiectasis, interstitial pneumonitis, emphysema, and tuberculous bronchopneumonia of the right lung. The left lung also showed irregular fibrosis and a few areas of caseation. Fibrinous pleurisy was present on the right.

The kidneys were small (70 grams each) and somewhat flabby. The cut surface was mottled with fine yellow dots in both cortex and medulla, the glomeruli could not be made out and the pelvis were moderately distended.

The wall of the cecum was thin, and the mucosa ulcerated, the ulcers showing slight induration and being oriented transversely.

The appendix was obliterated distally.

The thyroid gland weighed 280 grams and measured 10 by 8 by 6 centimeters in size. It was moderately firm in consistency and coarsely lobulated. The cut surface had a homogeneous appearance and a yellow color but was not greasy, nor did it present the waxy appearance usual for amyloid-containing organs. Irregular lobulations could be made out but no colloid could be recognized. Applica-

tion of Lugol's solution to the cut surface resulted in a typical mahogany brown color reaction characteristic of amyloid.

The trachea showed compression with narrowing of the lumen just below the thyroid cartilage, the tracheal rings at this point were softened and displaced toward the left.

The histological findings were:

The arterioles of the myocardium showed abundant deposits of amyloid in the intima. Moderate perivascular fibrosis was present, and the endocardium was irregularly thickened.

The lungs showed organizing acute fibrinous pleurisy, dilated bronchi with desquamated epithelium and peribronchial round cell infiltration, areas of diffuse fibrosis and thickening of the framework with considerable chronic inflammatory reaction, extensive areas of atelectasis and caseous bronchopneumonia with a few giant cells and granulomatous foci. Many arterioles showed great thickening of the wall with deposits of amyloid in the intima.

The liver showed capsular thickening with perportal fibrosis and congestion of the central zone with some atrophy and necrosis. Many of the arterioles showed deposits of amyloid in the intima.

The spleen showed amyloid in the intima of the arterioles and small amounts of amyloid in the malpighian bodies. No amyloid as seen in the pulp.

The intima of the arterioles in the adrenal glands contained amyloid, and there were few scattered mononuclear cells in the medulla.

The kidneys showed extensive diffuse fibrosis of the cortex and medulla with marked degeneration of the convoluted tubules and diffuse chronic inflammatory reaction. Nearly every glomerulus showed some deposit of amyloid, the majority being largely replaced by this material, which as also present in the intima of many of the smaller arteries and arterioles. Many of the surviving convoluted tubules were dilated, contained hyaline and amyloid cast, and numerous polymorphonuclears in some instances. Irregular masses of amyloid were present in the stroma of the medulla.

The all of the cecum showed ulceration, chronic inflammatory granulation tissue, and few focal granulomatous lesions but no definite tubercles.

The capsule of the thyroid was not thickened. The lobulation was essentially distinct. The usual colloid-containing follicles were almost completely absent, the bulk of the organ consisting of extensive masses of amyloid material in some areas. Follicular structure suggesting the appearance of hyaline fibrous tissue. Numerous islands of fat cells were intermingled with the amyloid, and in some sections the amount of fat tissue was approximately as great as that of the amyloid. Occasionally thyroid follicles containing colloid could be recognized. In some instances the follicles were cystic, lined by cuboidal epithelium, and contained mucus but few degenerated epithelial cells. These cystic follicles rested directly in contact with the amyloid in the adjacent stroma and in some instances amyloid appeared in the basement membrane which was considerably thickened thereby. In most sections the follicles were reduced to narrow slit-like spaces small, without epithelial lining although few degenerated epithelial cells could occasionally be recognized. Areas not so heavily infiltrated with amyloid the capillaries showed ring of this material forming sort of basement membrane for the endothelium, which was evident and showed some tendency to proliferation. Isolated multi-nucleated giant cells, occurring singly or in small groups (Figs 3 and 4), were fairly frequently seen. Phagocytosis of amyloid could not be demonstrated. There were also scattered focal accumulations of lymphoid cells lying in the lower medullary connective tissue and fat tissue in various sections (Fig. 5).

The periacinar and perifollicular location of the early amyloid deposits suggested that the material had first made its appearance between the endothelium of the capillaries and the basement membrane of the follicles, and that as the amount of amyloid increased, there had been gradual compression of the follicles with resorption of the colloid and atrophy of the epithelium, ultimately resulting in almost complete replacement of the parenchyma by amyloid.

Application of Löffler's solution to the gross material and staining of the microscopic preparations with Congo red and methyl violet gave the typical staining reactions for amyloid in the thyroid, kidney, adrenal glands, arterioles of the heart, spleen, lungs, liver, and pancreas. Staining with Sudan III demonstrated considerable amounts of fat tissue in the thyroid and fat droplets in the convoluted tubules of the kidney.

The final anatomical diagnosis was: chronic bronchocystitis (tuberculous), chronic interstitial pneumonia, left aortic atherosclerosis, compensatory right emphysema, tuberculous bronchopneumonia, cystic capyema, acute fibroses

pleurisy, right hydrothorax, generalized amyloidosis, in particular involvement of the thyroid gland, kidney, spleen and the arterioles of the heart, lungs, liver, and pancreas, chronic atrophic colitis, edema of the liver, chronic thyroiditis, with extensive lymphocytic growth and arteriosclerosis, coronary atherosclerosis, chronic myocarditis, hypertrophy and dilatation of the heart, chronic passive congestion of the liver and kidneys, right auricular hemiatresia, obliterating appendicitis.

Case A, a male, aged 53 years, was admitted to the University of Kansas Hospital on the service of Dr. S. H. Bender complaining of tuberculosis. The previous admission he had noted weakness, dyspnea, liver enlargement, increased expectoration. Had lost weight, was found in the hospital and the patient was put to bed. Some time later the family changed physicians, and the attending physician allowed the patient to resume ordinary activities, stating that he "forgot his greater and that the pulse was too rapid."

Three weeks prior to admission the patient attended the out-patient clinic of the University of Kansas Hospital, where diagnosis of far advanced pulmonary tuberculosis was made on the basis of x-ray findings and the presence of tubercle bacilli in the sputum.

Physical examination on admission showed pale emaciated individual, with atrophy of the left upper thorax and atrophic scapular muscles, and numerous scars over the upper chest bilaterally. The heart rate was 94, blood pressure, 90 systolic and 50 diastolic, right, 91 pounds.

X-ray study revealed active bilateral tuberculosis of the lungs with cavitation.

The progress after admission was slowly but increasingly downward. Seven months after admission, coming after weeks of paroxysms of coughing, dyspnea and anorexia associated with abdominal distention, distention, and tenderness. A diagnosis of tuberculous enteritis was made at this time and peritonitis was suspected. This was maintained for many months without any improvement of symptoms. Seventeen months after admission the right phrenic nerve was crushed, but this did not result in any tendency to breathing in the right lung. Twenty months after admission large neural symptoms appeared and were now as very marked. A more so palpated in the left abdomen on the left, and fluid detected in the abdomen 4 months after admission. Abdominal distention developed at about the same time and shortly thereafter fatal hemorrhage of congested liver resulted 95 to 100 per cent retention of the dialysis. Hemorrhage developed at this time and repeated abdominal paracentesis yielded approximately 5 liters of fluid over period of months.

Death occurred 44 months after the patient's admission to the hospital.

The final clinical diagnosis was: pulmonary tuberculosis, cavitation, tuberculous enteritis and peritonitis, bilateral large cystitis, generalized amyloidosis due to tuberculosis.

At postmortem examination the following data were obtained:

The body weighed 75 pounds and measured 5 feet 10 inches in length.

The pleural cavities showed complete symplectosis. There were bilateral tuberculous lesions of the bronchocystitis type with multiple cavities, tuberculous hilar lymphadenitis, tuberculous enteritis and peritonitis, tuberculous of the adrenal glands.

The liver and spleen were enlarged, firm, and rubbery in consistency and mottled orange in color. The adrenal glands showed the same mottled coloring but were not enlarged or hard.

The thyroid gland was not enlarged (weight 10 grams), it was light reddish brown in color, firm in consistency, and the cut surface showed a homogeneous appearance, no colloid could be recognized.

The orange red mottling of the liver, spleen and adrenal glands and the reddish brown color of the thyroid were apparently due to congo red staining of the amyloid in these organs as a result of intravenous administration of the dye during life.

The results of histological examination were

Amyloid deposits were found consistently in the stroma frequently in the intima of the arterioles and occasionally in the venules of the heart, lungs, liver, spleen, adrenals, kidneys, pancreas, small intestine, prostate, many lymph glands and the omentum. Hyperplastic fibrous tuberculous lesions were present in the lymph glands, lungs and adrenals, and a few tuberculous cavities were seen in the lungs.

A few areas of fat necrosis with moderate acute inflammatory reaction were present in the pancreas.

The vocal cords showed bilateral tuberculosis.

The capsule of the thyroid was not thickened, the lobulation was unusually distinct. The stroma of the gland was extensively infiltrated with amyloid. In most areas the follicles were atrophic and lined with cuboidal or low columnar epithelium showing a tendency to desquamation. The colloid presented a variable appearance, being smooth and homogeneous in some follicles while in others it was granular, greatly retracted and sometimes vacuolated. Few follicles remained in most fields and these were reduced to cleft like spaces with degenerated lining cells. The bulk of the gland consisted of amyloid material having a fibrillar structure much like hyaline fibrous tissue. The capillaries were very difficult to identify because of their resemblance to the numerous clefts in the section; the endothelium was poorly defined and appeared degenerated. Amyloid was present in the intima of many arterioles. There was no lipomatosis in this gland and no evidence of an inflammatory process was found.

The final anatomical diagnosis was: chronic pulmonary tuberculosis with cavitation, tuberculous laryngitis with ulceration, tuberculous enteritis, omentitis, lymphadenitis and chronic adhesive pleurisy with complete synechia, chronic adhesive perihepatitis and perisplenitis, generalized amyloidosis with particular involvement of the liver, spleen, pancreas, adrenal glands, kidneys, lungs, heart, intestine (colon), prostate, lymph glands, small intestine, omentum and thyroid gland. Emaciation, acute dilatation of the heart, Decubitus ulcers, accessory spleen, fat necrosis of the pancreas.

The response to application of Lugol's solution to the gross and methyl violet to the histological preparations was in every way typical for amyloid.

In 1893 Wichmann classified amyloid disease into generalized and localized forms. In 1929 Lubarsch recognized an essential difference between various forms and grouped them into typical or generalized and atypical or systematized forms. Since this paper appeared many other terms have been introduced. Thus such terms as typical, genuine, classical, visceral, generalized, orthochromatic, pericapillary and periglandular have been applied to the form of amyloid disease which is often associated with some chronic illness. The atypical form has been designated as primary, unusual, idiopathic, sys-

tematized, paramyloidosis, etc. Reimann, Koucky, and Eklund in 1935 discussed the various terms here mentioned and suggested a simple clinicopathological classification into 4 groups, primary amyloidosis, tumor forming amyloid disease, secondary amyloidosis, and amyloidosis with multiple myeloma.

The cases reported herewith are obviously examples of the secondary type of amyloidosis, unusual in that the thyroid gland showed extensive deposits.

In none of the reported cases was there any evidence of thyroid insufficiency, on the contrary, the first case reported herewith had an elevated basal metabolic rate, probably due to dyspnea.

In the first case here described amyloid infiltration of the thyroid was associated with lipomatosis as well. In view of the fact that the thyroid is an organ in which fat tissue is extremely rare, this finding would suggest that there may be some more than casual relationship between the two conditions. That this is possible is supported by the fact that a search of the literature reveals several other examples in which amyloid infiltration has been associated with lipomatosis. Thus Virchow mentioned the observation of fat tissue in the stroma of a thyroid containing amyloid in some fetal adenomas. (This case is not discussed specifically but is included among the 10 cases discussed by Peters.) Ecoffey found fat tissue in the center of an amyloid tumor of the larynx, Oberling found much fat in the thyroid of his case of amyloid goiter, and he mentioned a similar finding in an amyloid tumor of the larynx and in the adrenals. These examples could no doubt be added to by a more minute search of the literature but it seems clear that the concomitant occurrence of lipomatosis and amyloid infiltration is probably more than a mere coincidence, although it must be admitted that fat tissue is by no means always a part of the picture of amyloidosis.

#### SUMMARY AND CONCLUSIONS

The literature of amyloid goiter contains reports of 56 cases. Two additional cases reported herewith bring the total to 58. The classification of amyloid disease suggested by Reimann, Koucky, and Eklund is accepted, and the cases reported are placed in the secondary type of that classification.

The following conclusions have been made:

1. The commonest primary disease associated with amyloid infiltration of the thyroid is pulmonary tuberculosis. Purulent bronchitis with bronchiectasis or neoplastic processes are less commonly the precursors.

2. Amyloid infiltration of the thyroid may occur as a part of a primary amyloidosis.

3. Amyloid infiltration of the thyroid without amyloid in any other organ is a very rare phenomenon, only 3 cases being found in the literature (Schüder, Oberling).

4. Amyloid infiltration of the thyroid gland causes enlargement and increase in consistency in the majority of cases but does not invariably do so.

5. Amyloid infiltration of the thyroid is sometimes associated with striking fat tissue infiltration as well. The possibility that this is more than a casual relationship is discussed.

6. In no case of thyroid amyloidosis reported has there been any evidence of insufficiency.

7. The most common error in diagnosis is to conclude that a malignancy is present when actually amyloid is responsible for enlargement and increase in consistency as well as nodularity of the thyroid. On the other hand amyloid may cause considerable enlargement of the thyroid without any change in consistency.

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# THE ESTROGEN SPARING EFFECT OF HYSTERECTOMY

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THAT hysterectomy is followed by changes in the remaining genital organs has been demonstrated in the rabbit (2, 24) as well as in the guinea pig (22, 23) and the rat (3). Some of these effects in the rabbit and rat are prevented by transplantation of the uterus (13, 35), so that it seems clear that the mechanism is an hormonal one. The most striking effect of hysterectomy in these animals is the prolongation of the life of the corpus luteum, and the changes in the other organs, notably the mammary gland, are due primarily to its continued function. Another experimental technique by which the corpora lutea may be maintained in a functional state beyond the usual time in the rabbit both in pseudopregnancy (1, 39) and in pregnancy (15) is the injection of estrogenic hormone. Since estrogen produced in the growing ovarian follicle is essential in the rabbit for the normal development and maintenance of the corpora lutea (37, 41), these two observations may be correlated if one supposes that the uterus, dependent as it is on estrogenic hormone for its growth and maintenance, uses it up. When the uterus is removed, less estrogen is used, there is more estrogenic hormone available, and the life of the corpora lutea is prolonged just as it is when estrogen is injected.

To test this hypothesis, experiments were devised to determine the effect of partial hysterectomy on the survival of the corpora lutea in pseudopregnant rabbits, and the effect of the injection of estrogen in intact and partially hysterectomized animals. For if estrogen is spared by total hysterectomy, it should also be spared, but to a lesser extent, if part of the uterus is removed, and since the corpora lutea can be prolonged beyond the usual time by the injection of estrogenic hormone, a dose of estrogen which would just fail to maintain them with the uterus intact, might be expected to prolong their function with part of the uterus removed. As is the case with any endocrine gland, function of the corpora lutea cannot be perfectly correlated with their histological appearance. Therefore, several reactions known to be dependent on the function of the corpus luteum, *progestin effects*, were used to determine the state of the corpora lutea.

## CRITERIA FOR DETERMINING FUNCTION OF THE CORPORA LUTEA

1 *The gross and microscopic appearance of the corpora lutea* At about the 16th day of pseudopregnancy in the rabbit, the corpora lutea begin to degenerate. They become pale and decrease in size. Histologically many of the lutein cells are smaller and their nuclei are pycnotic. These cells stain more deeply with eosin, so that the corpus luteum has a mottled appearance under the low power magnification. Vacuolization is more widespread and the vacuoles are larger than those seen in lutein cells at the height of their function. There is an irregular increase in connective tissue throughout the corpora lutea and infiltration of wandering cells of varying degree.

These changes in the corpora lutea of the rabbit following pseudopregnancy have been described in detail and compared with the changes which occur after total or nearly total hysterectomy by Loeb and Smith (24). Degenerative changes, although similar, occur much later in hysterectomized animals. Even at 50 days the remnants of the corpora are larger in hysterectomized animals than in intact animals. The preservation of the corpora lutea in totally hysterectomized animals is shown by rabbit Y 345, Table II. There were no more signs of degeneration in the corpora at 26 days than may be seen at 12 days in the intact animal.

TABLE I—ANIMALS WITHOUT CORPORA LUTEA GIVEN ESTROGEN

Estrus Animals						
Rabbit number	Daily dose of estradiol benzoate—rat units*	Day mated (from beginning of treatment)	Day examined (from beginning of treatment)	Ovulation	Reaction of uterus <i>in vitro</i> to pituitrin	Progestin effect in endometrium
Y 418	40 to 160	10	20	No	C++	None
Y 419	40 to 160	10	20	Yes	C+++	None
Castrated Animals*						
Y 987	20	—	16 21	— —	C+++ C+++	None None
Y 988	20	—	16 21	— —	C+++ C+++	None None
Y 417	40 to 160	Mating refused days 18 and 23	23	—	C+++	None

\*6000 rat units = 1 mgm

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TABLE II—PSEUDOPREGNANT ANIMALS WITH VARYING AMOUNTS OF THE UTERUS REMOVED

Rabbit number	Estimated amount of uterus remaining	Day mated	Days examined	Ovulation	Reaction of uterus as noted in peritoneum	Macroscopic appearance of corpora lutea	Presence of shift in endometrium
Y 315		—	10 <sup>th</sup>	—	—	Well preserved	—
		Mating refused	20	—	—	Extreme degeneration	—
Y 369	75%	—	—	—	—	Beginning degeneration	None
Y 18	35	23	29	Yes	N	Beginning degeneration	None
Y 26	75%	—	29	Yes	N	Advanced degeneration	None
Y 27	5	—	29	—	N	Advanced degeneration	None
Y 26	3	Mating refused	—	—	N	Well preserved	Marked shift
Y 455	15%	25	29	Yes	N	Extreme degeneration	None
Y 366		Mating refused	29	—	N	Advanced degeneration	None
Y 434	20%	Mating refused	29	—	C++	Extreme degeneration	None
Y 5	25	21	23	Yes	C++	—	—
Y 433	42%	24	29	Yes	C++	Extreme degeneration	None
Y 379		Mating refused	23	—	C++	Advanced degeneration	None
Y 364		—	23	—	N	Generally well preserved	Marked shift
Y 30	/	—	20	—	C++	Beginning degeneration	None
		24	24	—	R+	Beginning degeneration	Moderate progressive degeneration
Y 34	25	—	20 <sup>th</sup>	—	C++	Well preserved	Marked shift
	/	—	25	—	C++	Extreme degeneration	None

\*One ovary was removed at this time.

With adequate dosage of estrogenic hormone degeneration of the corpora lutea can be prevented in pseudopregnant rabbits with a fertility for more than twice the usual life span of the corpora. For example the corpora of Y 433 and Y 144, Table III, showed no signs of degeneration at 35 days.

In the tables, the appearance of the corpora lutea by histological examination are indicated by the following: well preserved, when no signs of degeneration are seen; generally well preserved, when signs of degeneration appear only in limited areas; beginning degeneration, when there are early signs of degeneration throughout; advanced degeneration, when there is degeneration throughout with some shrinking of the corpora lutea; and extreme degeneration when there are advanced degenerative changes with marked shrinking of the corpora.

3. *The histological appearance of the endometrium.*—The pregestational proliferation (transformation) of the endometrium regresses after about the 5th day in pseudopregnancy and by the 14th day has usually returned to the condition of estrus. A change in the surface epithelium of the endometrium is sometimes seen to a slight extent in late pseudopregnancy. It consists of an apparent fusion of the cytoplasm of the superficial cells forming what appear to be large giant cells, which are subsequently shed into the lumen. During pregnancy in the sterile uterine horns of rabbits pregnant in one horn of the uterus, the process becomes extensive. The superficial cells become fused over large areas and form a sort of neovivarium lining the lumen of the uterus (Fig. 1). This change occurs in castrated rabbits treated with both estrogenic hormone and progesterone over long periods. It has been de-

TABLE III—PSEUDOPREGNANT ANIMALS WITH UTERUS INTACT, GIVEN ESTROGEN

Rabbit Number	Daily dose of estradiol benzoate—rat units	Day injections began	Day mated	Day examined	Ovulation	Reaction of uterus <i>in vitro</i> to pituitrin	Microscopic appearance of corpora lutea	Progestin effect in endometrium	Weight of uterus—grams	Number of corpora lutea	Weight of animals—grams
Y 380	20 to 40	11	Mating refused	22	—	C+++	—	None	—	—	—
Y 383	60	11	— 22	21 26	— Yes	C+++	—	None	—	—	3240
Y 306	20 to 80	13	9	20	No	C+++	Beginning degeneration	Slight perivascular change	—	—	4740
Y 405	0 to 80	11	20	30	Yes	C++	Extreme degeneration	None	—	—	3333
Y 413	20 to 80	11	9	20	Yes	C++	Extreme degeneration	None	87	5	600
Y 414	20 to 80	11	8	20	No	C+++	Generally well preserved	Perivascular change	51	6	3060
Y 356*	20 to 80	12	28	20	No	N	Well preserved	None	116	7	3020
Y 3,6*	20 to 80	1	28	20	Yes	C+	Advanced degeneration	None	254	10	5420
Y 417	0 to 80	11	Mating refused	20	—	C+—	Well preserved	Slight surface change	84	11	3000
Y 404	40 to 160	11	Mating refused	20	—	C+++	Advanced degeneration	Perivascular change	2.5 cm segment	9	3020
Y 405	40 to 160	11	28	20	No	R+	Generally well preserved	Some progestational proliferation, perivascular change and necrosis	2.5 cm segment 1.4	11	3560
Y 408	40 to 160	11	8	30	No	C++	Beginning degeneration	Perivascular change, necrosis	99	6	2650
Y 409	40 to 160	11	20	30	No	C++	Beginning degeneration	Perivascular change, necrosis	85	7	3030
Y 411	40 to 160	11	28	20	Yes	C++	Advanced degeneration	Perivascular change	107	74	3530
Y 143	20 to 400	11	—	35	—	—	Well preserved	Perivascular change, necrosis extensive	—	—	5240
Y 144	20 to 400	11	—	35	—	—	Well preserved	Surface change	—	—	4030

\*One ovary previously removed

scribed by Loeb in association with deciduomata in the rabbit (21) and it is seen when the life of the corpora lutea has been prolonged by estrogen (4). It does not occur in the absence of the corpora lutea unless progesterin has been injected. Its presence, therefore, is evidence of corpus luteum function.

The appearance of the endometrium is variable in animals whose corpora have been maintained anatomically beyond the usual time of pseudopregnancy (39). The endometrium may be in the estrus condition or it may show varying degrees of progestational proliferation. If large enough doses of estrogen are given, necrosis involving the muscle as well as the endometrium is pro-

duced. The necrosis is always seen in association with the perivascular change, a decidual-like reaction occurring in the cells of the tunica muscularis of the arterioles of the lamina propria of the mucosa and the muscularis of the uterus (Fig 1, c, d). It consists of enlargement of the cells with vacuolization and rarefaction. In extreme cases it seems also to involve the smooth muscle of the uterine wall in association with necrosis. With somewhat smaller doses of estrogen the perivascular change is seen in the absence of any necrosis. These changes do not appear in animals without corpora lutea, that is, estrus animals or castrates injected with estrogen, Table I, but they are seen in castrated animals injected with



b



d

Fig. 1. a, Section of uterus from rabbit V 300 (Table IV) showing epithelial surface change (X 4). Note similarity to b. With part of the uterus removed, this animal received an optimum dose of estrogen for maintenance of the corpora lutea so that the progesterone-estrogen balance was normal. b, Sterile uterine horn of unilaterally pregnant rabbit on the 5th day of pregnancy showing epithelial surface change (X 4). c, Section of uterus from rabbit V 405 (Table III), showing perivascular change and necrosis, indicating insufficient progesterone in relation to estrogen. d, Necrosis, involving mucosa and muscle. f, Perivascular change in mucosa and muscle. With intact uterus, this animal received insufficient estrogen for adequate maintenance of the corpora lutea so that there was insufficient progesterone to balance the estrogen (X 10). d, Higher magnification of boxed area, showing perivascular change (X 67).

both estrogen and progesterone in which the amount of estrogen has been too great for the production of the epithelial surface change of late pregnancy. They indicate therefore, an amount of estrogen which is excessive in relation to progesterone.

3. *The reaction of the uterine muscle to pituitrin *in vitro*.* A piece of rabbit uterus suspended in Ringer Locke solution contracts when pituitrin is added to the bath if the animal has been in estrus, but during pseudopregnancy or the early part of pregnancy the muscle is refractory to pituitrin (7-20). It either fails to respond or relaxes. The failure of the uterus to contract to pituitrin is due to the presence of corpora lutea in the ovaries. It has further been shown by injecting estrogen and progesterone in castrated rabbits that pro-

gesterone is responsible for the failure of the uterus to contract when pituitrin is added to the bath (4, 41). There are three types of reaction to pituitrin: (1) contraction, (2) no response in which the pattern of the spontaneous contractions is not disturbed, and (3) relaxation of any degree. In general, relaxation is seen when the function of the corpora lutea is most active as judged by the microscopic appearance of the endometrium and of the corpora lutea in pseudopregnancy and pregnancy, that is, from the 6th to the 15th day in pseudopregnancy and from the 6th to 25th day in pregnancy. Figure 2, c, in castrated rabbits given both hormones, relaxation is seen when the endometrium shows changes like those of pregnancy (sterile horn). These changes are pregestational proliferation and later

if the injections are continued, surface change. If the amount of estrogen is excessive in relation to progesterone, the uterus contracts to pituitrin, and this may be seen in association with the perivascular change and necrosis.

4 *The occurrence or non-occurrence of ovulation after mating.* Ovulation in the rabbit does not occur during pseudopregnancy because of the presence of corpora lutea in the ovaries (11). That progesterone is responsible for this inhibition has been shown (26). Estrogenic hormone alone does not inhibit ovulation (30).

#### THE EXPERIMENTS

The experiments fall into three groups (1) Pseudopregnant animals with varying amounts of the uterus removed were examined at various times after the 16th day. The purpose of these experiments was to determine whether partial hysterectomy tends to prolong the life of the corpus luteum. It has been stated to do so in the guinea pig (22, 23). If the theory be correct that removal of the uterus results in maintenance of the corpora lutea because estrogen is thereby spared, this may occur, for partial hysterectomy might be expected to have the same effect as injection of estrogen. (2) Pseudopregnant animals with the uterus intact, and others with part of the uterus removed were given similar doses of estrogen. If the uterus uses estrogen, removal of part of it should result in a decrease in the amount used and should increase the effectiveness of injected estrogen in prolonging the life of the corpora lutea. A dose of estrogen, then, just too small to maintain the corpora lutea in animals with the uterus intact, should maintain them in partially hysterectomized animals. (3) Pseudopregnant animals with intact uteri were given a dose of estrogen inadequate to maintain the corpora lutea and then these same animals, after part of the uterus had been removed, were given the same or a smaller dose of estrogen during a second pseudopregnancy. The subminimal dose of estrogen with the uterus intact should be sufficient to maintain corpora lutea with part of uterus removed.

Sexually mature rabbits kept in separate cages were used in the experiments. Ovulation was induced by mating or by the injection of pregnancy urine. The occurrence of ovulation was checked the following day by laparotomy at which time the tubes were tied off, if ovulation had been induced by mating. If part of the uterus was to be removed, it was done at this time. At the termination of the experiments, uterus and ovaries were fixed in Zenker's solution and formalin and sectioned. The uteri with the mesometrium

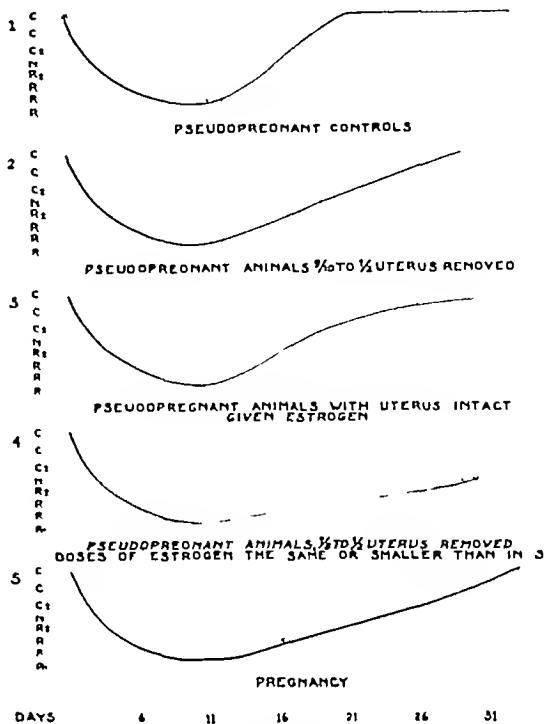


Fig. 2. The abscissas represent days following mating or the induction of ovulation by injection of pregnancy urine. The ordinates indicate the type of response to pituitrin of the uterine muscle *in vitro*. C++ an extreme, clus type contraction. V, No change in the spontaneous contractions. R+++ Relaxation of the muscle with inhibition of spontaneous contractions for 10 minutes or more. The intermediate points represent less extreme reactions.

trimmed close to the wall were weighed on a rough balance as soon as possible after removal. The percentage of uterus remaining was calculated from the weight of uterus removed at operation and that remaining at the end of the experiment. The weights and percentages are therefore only approximate. The reaction to pituitrin of the uterine muscle was tested by suspending a segment of uterus about 2 centimeters long in 125 cubic centimeters of Ringer's solution and recording the contraction on a kymograph. After spontaneous contractions had been established, first 0.5 unit and then 1 unit of pituitrin were added to the bath. The most extreme reaction obtained in each case has been recorded in the tables and plotted in Figure 2.

#### EXPERIMENTAL OBSERVATIONS

*Group 1.* Pseudopregnant animals with varying amounts of the uterus removed were examined

TABLE IV—PSEUDOPREGNANT ANIMALS WITH PART OF THE UTERUS REMOVED GIVEN ESTROGEN

Rabbit Number	Daily dose of estradiol benzoate, rat units	Day to parturition begins	Day anesthetized	Days removed	Ovarian condition	Reaction of uterus as color in pituitary	Macroscopic appearance of corpora lutea	Pregnancy effect in remaining uterus	Apparent amount of uterine remaining		Number of corpora lutea	Age of animal from birth
									Proportion	Grains		
Y 37	20 to 40		Matings refused	25	—	N	—	Slight surface changes	1	—		
	80	25	Matings refused	26	—	N	Generally well preserved	Slight perivascular changes	2	—		
Y 41	20 to 30		—	26	—	R++	Well preserved	Some progestational prolif. evident				200
200	20 to 30		Matings refused	29	—	R	Beginning degeneration	Marked surface changes				200
Y 40	20 to 30		25	29	No	C++	Generally well preserved	Perivascular changes				200
Y	20 to 30		25	29	No	R+++	Generally well preserved	Surface changes				200
Y 370	20 to 30		Matings refused	30	—	C+	Others lost	Perivascular changes, necrosis				200
Y	20 to 30		Matings refused	30	—	R+	Beginning degeneration	Slight perivascular changes, some progestational prolif. evident	4			
Y	20 to 30		26	30	No	+	Well preserved	Slight surface changes				270

at various times after the 6th day (Table II). One total hysterectomized animal, Y 345 (cervices remaining) showed well preserved corpora lutea; one ovary removed on the 26th day. At 50 days, the corpora in the remaining ovary were degenerate. Animals with nine-tenths to three-quarters of the uterus removed showed evidence of maintained function of the corpora lutea beyond 16 days as indicated by the reaction to pituitrin of the uterine muscle and in some cases by the histological appearance of the corpora lutea but not by any of the other criteria. There were well preserved corpora in Y 363 and Y 365 on the 18th day, as well as slight evidence of continued progestational stimulation of the cervix, but this may be seen normally at this time as shown by Y 34. The reaction to pituitrin of uterine muscles in these animals is shown graphically in Figure 2. Y 36 is of interest. At 1 day with nearly all the uterus remaining there were no signs of maintenance of the corpora. At that time one half of the uterus, one horn and one ovary were removed. Five days later the uterine muscle was refractory to pituitrin, and there was fair progestational proliferation of the endometrium. The corpora lutea of the remaining ovary although generally showing signs of degeneration, looked better preserved than would be expected

from the appearance of the corpora in the ovary which had been removed 12 days. This probably indicates a return of function of the corpora in the remaining ovary after partial hysterectomy. Removal of one ovary appears to have no such effect, as shown by Y 34, an animal with nearly all of the uterus remaining in which one ovary was removed on the 8th day without any apparent effect 60 days later.

**Summary group 1.** Removal of part of the uterus in the rabbit prolongs the life of the corpora lutea of pseudopregnancy and the degree of prolongation appears to be proportional to the amount of uterus removed.

**Group 2.** Pseudopregnant animals with the uterus intact and others with part of the uterus removed were given similar doses of estrogen. The results are shown in Tables III and IV. Estradiol benzoate progestin B<sub>1</sub> as injected subcutaneously beginning on the 13th to 15th day of pseudopregnancy. In most cases the dose was doubled after the 5th and 20th days. In some they were doubled only once and the same dose was given from the 16th day on. Y 121 and Y 124 animals with intact cervix in which the amount of estrogen was adequate to maintain the corpora lutea received 20 rat units from 11th to 15th days, 60 rat units from 16th to 20th day.

TABLE V—PSEUDOPREGNANT ANIMALS GIVEN ESTROGEN WITH UTERUS INTACT AND THEN WITH PART OF UTERUS REMOVED

## First pseudopregnancy—uterus intact

Rabbit number	Daily dose of estradiol benzoate—rat units	Day injections begun	Day mated	Day uterus removed	Ovulation	Reaction of uterus <i>in vitro</i> to pituitrin	Progestin effect in endometrium
Y 415	20 to 80	11	28	29	Yes	C++	None
Y 424	30	11	28	30	Yes	C+	None
Y 425	30	13	28	29	Yes	C++	None
Y 426	30	13	28	29	Yes	C++	None
Y 427	30	11	28	29	Yes	C++	—

## Second pseudopregnancy—part of uterus removed

Rabbit number	Approximate amount of uterus remaining		Daily dose of estradiol benzoate—rat units	Day injections begun	Day examined	Day mated	Ovulation	Reaction of uterus <i>in vitro</i> to pituitrin	Progestin effect in endometrium	Microscopic appearance of corpora lutea	Number of corpora lutea	Weight of animal—grams
	Grams	Percent										
Y 415	1.4	19	20 to 40	11	30	29	No	N	Some progestational proliferation	Well preserved	7	3860
Y 424	1.6	18	30	11	30	29	No	N	Surface change	Generally well preserved	12	5060
Y 425	2.3	27	30	13	29	28	No	R++	Surface change	Well preserved	14	4860
Y 426	4.1	35	30	13	30	29	No	C++	None	Generally well preserved	14	3890
Y 427	2.3	26	30	11	29	Mating refused	—	R++	Marked surface change	Well preserved	10	3800

## Controls—part of uterus removed, no estrogen

Rabbit number	Approximate amount of uterus remaining		Day mated	Day examined	Ovulation	Reaction of uterus to pituitrin	Progestin effect in endometrium	Microscopic appearance of corpora lutea	Number of corpora lutea	Weight of animal—grams
	Grams	Percent								
Y 434	1.8	28	Mating refused	29	—	C++	None	Extreme degeneration	8	3790
Y 435	2.3	42	28	29	Yes	C+	None	Extreme degeneration	9	3825
Y 436	1.7	22	28	29	Yes	N	None	Advanced degeneration	8	3650
Y 438	1.3	24	28	29	Yes	N	None	Extreme degeneration	9	3390

200 rat units from 21st to 25th days, and 400 rat units from 26th to 35th days. Most of the experiments were continued for 29 or 30 days. It will be noted that in the 7 animals with intact uterus given 20 to 80 rat units of estrogen a day, only 11 of 27 criteria indicated prolongation of the corpora lutea (Table III). In 8 animals with part of the uterus removed, on the other hand, 22 of 26 criteria indicated maintenance, none of the corpora showed more than beginning degeneration,

and the endometria in all cases showed some evidence of the action of progesterone (Table IV). Even with twice this dose of estrogen, 40 to 160 rat units a day, 9 of the 19 criteria in 5 animals with the uterus intact indicated degeneration and the corpora lutea in 2 cases showed advanced degeneration (Table III). It is interesting that when the dose was larger, 40 to 160 rat units a day, perivascular changes were seen in the uterus. This is the result of larger amounts of estrogen

which were still insufficient to maintain the corpora lutea adequately for as has been noted, perivascular changes are seen when there is an excess of estrogen in relation to progesterin. The corpora lutea in these animals were degenerating, so that the amount of progesterone they were producing was smaller in relation to the estrogen than in the animals receiving less estrogen. The more normal proportion of estrogen and progesterone associated with maintenance of the corpora lutea is indicated by the surface change since it appears in extreme degree in the sterile horn of unilaterally pregnant animals, in which perivascular changes and necrosis are not seen. Accordingly the surface change is seen only in cases in which most of the other criteria indicate maintenance of the corpora lutea, for in these the corpora lutea were adequately prolonged and there was no excess of estrogen.

**SUMMARY OF GROUP 2.** Amounts of estrogen insufficient to prolong the life of the corpora lutea in animals with intact uteri, prolonged it in animals with part of the uterus removed as indicated by the majority of the criteria for determining the function of the corpora lutea.

**GROUP 3.** The thesis that partial hysterectomy spares estrogen, and its corollary that the amount of uterus determines how much estrogen will be necessary to maintain the corpora lutea, is most strikingly supported by this group of experiments. Five pseudopregnant rabbits with intact uteri were given doses of estrogen considered to be inadequate to maintain the corpora lutea. One received 30 to 80 rat units a day, the dose being doubled on the 16th and 21st day and the rest received 30 rat units a day throughout (Table V). On the 28th day all of the animals mated. Subsequent examination revealed that ovulation had occurred in all cases and the gross appearance of the old corpora as well as the other criteria indicated that the corpora lutea were degenerated. Part of the uterus was removed at this time, and then during this second pseudopregnancy the animals were treated the same as they had been previously except that one received a smaller amount of estrogen, and were examined a day later the 30th rather than the 29th. Four of the animals this time failed to ovulate (one would not mate) and except for V 426 in which the uterus was sensitive to pituitrin and the endometrium had returned to the condition of estrus, all of the criteria indicated maintenance of the corpora lutea in all of the animals. V 426 retained more of the uterus than any of the other animals 4.1 grams, 35 per cent as calculated from the amount of uterus removed at the start of the

experiment and that remaining at the end. Thus all of the criteria indicated degeneration when the uteri were intact, while with approximately 18 to 35 per cent of the uteri remaining, 17 of 19 of the criteria indicated maintenance. Rabbit V 415 in which the experiment in group 1 was run between the first and second parts of group 3 with only a little more uterus (some had to be removed for testing *in vivo*) showed no signs of maintenance of the corpora on the 22nd day 7 days earlier than the termination of the experiments in group 3. As further controls in these experiments, 4 pseudopregnant rabbits with comparable amounts of the uteri remaining, approximately 22 to 42 per cent received no estrogen (Table V). These animals, also included in Table II showed degeneration in 13 of 15 criteria on the 29th day. Those with the smaller amount of uterus remaining, approximately 22 and 24 per cent showed failure of the uteri to contract to pituitrin. All of the other criteria indicated degeneration of the corpora lutea.

**SUMMARY OF GROUP 3.** An amount of estrogen insufficient to prolong the life of the corpora lutea with the uterus intact, prolonged it in a second pseudopregnancy when part of the uterus had been removed. All of the criteria in 5 animals indicated degeneration of the corpora lutea when the uteri were intact. With part of the uterus removed 7 of a total of 19 criteria indicated maintenance of the corpora lutea. The animal in which 3 of the criteria indicated degeneration of the corpora was the one retaining the most uterus. Four rabbits with comparable amounts of uterus removed, given no estrogen, showed degeneration of the corpora lutea in 13 of 15 criteria. The 3 animals in which one of the criteria indicated maintenance of the corpora were those retaining the smaller amounts of uterus.

#### ANALYSIS OF THE CRITERIA

It is apparent from the data that no single criterion is reliable as an index of the function of the corpora lutea. The occurrence of ovulation after mating may be misleading, for animals will not always mate and when they do ovulation may fail to occur even though there may be no corpora lutea (V 418 Table I).

The reaction of the uterine muscle to pituitrin in the various experiments is represented graphically in Figure 2 in which it is compared with the reaction of the muscle in pseudopregnancy and pregnancy (sterile horn). It will be noted that in partially hysterectomized animals pseudopregnancy is prolonged, that is, the curve of reactivity of the muscle to pituitrin (Fig. 2) is more like

that of pregnancy (Fig 2, 5) in which the corpora are naturally prolonged. In pseudopregnant animals with the uterus intact given an amount of estrogen which in general failed to prolong the life of the corpora, the curve (Fig 2, 3) is little different from that of normal pseudopregnant animals (Fig 2, 1). In pseudopregnant animals with part of the uterus removed given the same or smaller doses of estrogen the curve (Fig 2, 4), is most like that of pregnancy, and many of the points indicate maintenance of function of the corpora even beyond that occurring in pregnancy. The *in vitro* reaction of the uterine muscle appears to be the most sensitive criterion of the corpus luteum function, for the small amount of progesterin produced by the histologically degenerate corpora lutea of Y 418, Y 436, and Y 438 (Table II), insufficient to prevent ovulation, was still enough to render the uteri of these animals refractory to pituitrin.

The microscopic appearance of the endometrium is of particular interest because, although it may indicate a state of estrus when other criteria indicate action of progesterone and hence alone is not a reliable criterion, it often indicates the relative proportion of estrogen and progesterone. When the corpora are adequately maintained and there is an excess of estrogen, perivascular changes and necrosis occur, for example, Y143 (Table III). These changes are also seen when the corpora lutea have been allowed to degenerate by the giving of too little estrogen and hence are again producing too little progesterone to balance the estrogen. The surface change is seen when most of the other criteria indicate optimal estrogen dosage for maintenance of the corpora. Progesterational proliferation 29 days after ovulation probably indicates insufficient dosage of estrogen, allowing the endometrium by insufficient stimulation of the corpora to regress to the condition of estrus and then, due possibly to the increasing dosage of estrogen, since it is seen only in animals in which the dose was increased, bringing about a late increase in production of progesterone. This theory is borne out by the findings in Y 36 (Table II) already discussed. Progesterational proliferation cannot be maintained beyond 16 days, it must be transformed into a late pregnancy type of endometrium (surface change) or it will regress to a condition of estrus (4). That slight perivascular changes are seen along with it in Y 422 (Table IV) is consistent with this. It indicates insufficient estrogen to maintain the corpora lutea adequately at an earlier time, allowing the original progesterational proliferation to regress and causing

slight perivascular changes. Then the increasing dose of estrogen revived the corpora, and progesterational proliferation began again.

The microscopic appearance of the corpora lutea is a good criterion, for although corpora which appear degenerate may still be producing a little progesterin as indicated by other criteria, well preserved corpora always prove to be functional, and in general the more degenerate the corpora appear the less evidence of function there is as indicated by the other criteria.

The number of corpora lutea seems to have nothing to do with whether or not they are maintained by estrogen. For example there was no evidence of maintenance in either Y 413 with only 5 corpora lutea or Y 376 with 10 (Table III). When the life of the corpora has been prolonged, however, the evidence of corpus luteum function is more complete when there are large numbers of corpora lutea. Thus in Table IV, in animals in which there are 11 and 12 corpora the evidence of maintenance is fairly complete, while in those with 5 or 6 there is evidence of degeneration in one or more criteria. Y 410 and Y 419 (Table IV) with 5 and 6 corpora lutea, respectively, were the only animals with part of the uterus removed to show contraction of the uterine muscle to pituitrin *in vitro*. They also showed the perivascular change and necrosis in the endometrium, signs of the action of both estrogen and progesterone with an excess of estrogen. It is probable that when there were more corpora, more progesterone was produced. This is reasonable, for a quantitative relation between the number of corpora lutea and the degree of progesterational proliferation in the rabbit has been shown (8, 16).

#### RELIEF OF MENOPAUSAL SYMPTOMS FOLLOWING SUBTOTAL HYSTERECTOMY

The question of whether hysterectomy in the human being has any effect on the endocrine system is an important one and, although there are numerous opinions, the evidence does not lead to an answer. The subject was reviewed by Reynolds in 1939 (31). The following case is of interest because it may represent the sparing of estrogen following hysterectomy in the woman.

M S, a 44 year old woman, tripara, who had experienced symptoms of hypoestrinism for more than a year and a half, needed a subtotal hysterectomy because of the presence in the uterus of fibromyoma causing pain and menorrhagia. The menopausal symptoms consisted of hot flashes, recurrent dizziness, and nervousness. During the year before operation, her symptoms had been relieved by the injection of estrogens. A dilatation and curettage, done before treatment with estrogen was begun, revealed normal endometrium. General physical examination was negative, blood count was normal, blood pressure was



ca/60. There was no evidence of trophy of the vaginal uterus and the vaginal uterus was normal. A 35 gram uterus containing 4 by 5 by 5 centimeter fibromyoma, as removed on the 31 day of menstrual period. Both tubes and ovaries and the cervix were left. Both ovaries were normal in size and appearance. One of them contained what appeared to be a slightly shriveled corpus luteum. Section of the uterus showed menstruating endometrium. Areas of the endometrium which are intact were thin and only scattered glands showed any evidence of secretion, suggesting that there had been little corpus luteum effect. For 3 1/2 months following operation the patient was entirely free of disturbance and nervousness, previously her most distressing symptoms, and she had only an occasional mild hot flash. Since the recurrence of her symptoms she has again been relieved by the injection of estrogens. Nervousness, manifested particularly by growing sensation in the epigastrium, has just begun to recur months after operation. A possible explanation of these observations is that the removal of the uterus spared the decreasing supply of estrogen to such an extent that the level at which symptoms of hyposteronism occurred was not again reached for 3 1/2 months. It is possible also, that the corpus luteum noted at operation was masculinized or revived for time, for there is evidence that the life of the corpus luteum in the human may be prolonged by estrogenic hormone (35). The findings in this case are not proof of an endocrine effect of hysterectomy for subjective symptoms of the type experienced in this case might be relieved by any operation, although the dilatation and curettage year before had no such effect. The appearance of the vaginal os and of the vaginal sensor are not available as criteria of estrogen action, since they were normal to start with. Assays of the excretion of estrogen, gonadotropic hormone, and pregnandiol, had they been done in this case might have supplied needed objective evidence.

It seems reasonable to conclude from the experiments presented that the prolongation of the life of the corpora lutea in the rabbit following hysterectomy is caused by the sparing of estrogenic hormone produced in the organism, probably by growing follicles in the ovaries. The work of Westman (37) and of Westman and Jacobsohn (41) has shown the importance of the production of estrogen by the graafian follicles for the normal development and maintenance of the corpus luteum in the rabbit.

It has been reported that hysterectomy is without effect on the ovarian cycle in the monkey (5) opossum (2), and rat (25, 28). In the case of the monkey and the opossum, the experiments do not prove that some prolongation of the life of the corpus luteum does not occur after hysterectomy but it appears that there is no prolongation comparable to that of the rabbit and guinea pig. In the rat the corpus luteum of pseudopregnancy that is, following mating or mechanical stimulation of the cervix, is maintained by hysterectomy while that forming spontaneously in the absence of mating normally lasting only about 4 days as compared with 8 to 12 in pseudopregnancy is unaffected (3, 13). It is reasonable to suppose that hypophyseal activity is responsible for the dif-

ferent behavior of the corpora lutea after mating or mechanical excitation of the cervix, since such a stimulus might produce greater or more prolonged secretion of gonadotropic hormone by the pituitary. The effect on the corpora lutea might be mediated through the ovarian cortex in the stimulation there of the production of estrogen. It is known that the corpora lutea of the rat can be maintained by the injection of estrogen in the absence of the hypophysis (33, 40), and that estrogen is essential for their normal development and maintenance (37, 41). It may be that in the rat, without increased production of estrogen stimulated in the ovary by the hypophyseal secretion resulting from copulation, there is insufficient estrogen, even after it is spared by hysterectomy to prolong the life of the corpora lutea beyond 4 days.

Evidence of the metabolism of the estrogens by the uterus has been brought forward (36). Whether the endometrium or the uterine muscle is more important in the utilization of estrogen or conversion of estrogen to less active compounds is a question which if answered, might help to explain the maintenance of the corpora lutea in the rat incident to uterine distention by wax pellets following pregnancy (34). The factor of estrogen sparing might be of importance if it were found that the endometrium is the greater user of estrogen for with distention of the uterus by wax pellets there would be some reduction of the endometrial mass by pressure, although the amount of muscle would be increased due to hypertrophy (32). Such a mechanism is suggested by an experiment not included in the foregoing data. Rabbit V 303 with one horn of the uterus removed received 20 to 80 rat units of estrogen, an amount usually insufficient to maintain the corpora in intact animals. On the 26th day examination revealed that the remaining uterine horn was greatly distended like the pyometrium, with resulting hypertrophy of the wall and complete destruction of the endometrium. The remaining uterine muscle weighed 35 grams as much or more than the normal intact uterus, yet the corpora lutea were generally all preserved microscopically perivascular changes were noted in the myometrium and the reaction of the muscle to pituitrin was C+ - indicating some activity of the corpora V 376 (Table III) with the same total weight of uterus received the same dose of estrogen but showed no evidence of maintenance of the corpora whatever. This suggests that in the animal with the pyometrium, even though there was more uterine muscle than normally sufficient estrogen was spared by the

absence of the endometrium to prolong the life of the corpora lutea

Whether the greater need for estrogen lies in the endometrium or the myometrium, it is clear that the size of the normal uterus determines the amount used. From this it is interesting to speculate on the possible significance of the underdeveloped, infantile uterus in women. It is conceivable that the production of estrogen by the ovaries might be such that, with the sparing effect of the undersized uterus, hyperestrinism of varying degree might result. If estrogen inhibits the gonadotropic activity of the hypophysis in the woman as it does in experimental animals (10, 27), it is possible that a relative excess of estrogen resulting from an undersized uterus might prevent normal establishment of the menstrual cycle. It is also possible that in some cases the excess of estrogen which produces hyperplasia of the endometrium might arise in this way. This condition may be produced experimentally in women as well as in experimental animals by the injection of estrogenic hormone in large amounts, and increased excretion of estrogen in the urine has been reported in association with it (42). It is accompanied by the persistence of a follicle in the ovary (failure of ovulation and corpus luteum formation). The idea that the pituitary is responsible for failure of proper development and rupture of the follicle is not new (43). The pituitary failure may not always be the primary cause, however. Like the hyperplasia of the endometrium, it might result from hyperestrinism, and the uterus, perhaps the endometrium itself, might cause the disturbance by not using up its share of estrogenic hormone. In a recent report of the production by estradiol benzoate of hyperplasia in castrated monkeys Cleveland, Phelps and Burch (7) noted that only in animals in which the amount of the uterus had been decreased by previous biopsies, was hyperplasia obtained. It seems in these experiments that the size of the uterus (the amount remaining) determined whether or not a given amount of estrogen would have a pathological effect on the endometrium. In the animals from which biopsy specimens had been removed from the uterus, the effective amount of estrogen was greater because there was less uterus to use it up.

If the underdeveloped uterus stops the normal endocrine balance by sparing estrogen which in turn inhibits the gonadotropic activity of the pituitary, enlargement of the uterus might be expected to remedy the situation by decreasing the estrogen level and allowing the hypophysis to stimulate the ovaries to more normal function. The ovarian enlargement observed following the

use of uterine stems (6, 9, 36), which by distention of the uterine cavity caused hypertrophy of the uterus, may be an evidence of this mechanism. Not only uterine and ovarian enlargement have been reported following the use of intrauterine stems, but the relief of amenorrhea, dysmenorrhea, and even sterility as well. It is possible that the uterus of inadequate size acts as a block to normal harmonic relations between the hypophysis and the ovaries by not using its share of estrogen. The evidence suggests that a quantitative balance may be essential between the production and utilization of estrogenic hormone for the normal function of the sexual organs in the female.

#### SUMMARY

The life of the corpora lutea of pseudopregnancy in the rabbit may be prolonged by removal of part of the uterus. The degree of prolongation appears to be proportional to the amount of uterus removed.

An amount of estrogen insufficient to prolong the life of the corpora lutea of pseudopregnancy in rabbits with intact uteri may maintain the corpora lutea beyond the usual time when it is given to rabbits with a part of the uterus removed.

An amount of estrogen insufficient to prolong the life of the corpora lutea in rabbits with intact uteri may prolong it in a second pseudopregnancy after part of the uterus has been removed.

The amount of estrogen necessary to prolong the life of the corpora lutea in partially hysterectomized rabbits is determined primarily by the amount of uterus remaining.

A case is presented in which menopausal symptoms in a 44 year old woman were relieved following subtotal hysterectomy, suggesting an estrogen sparing effect in the human being.

The possible relation of sparing of estrogen to the maintenance of the corpora lutea in the rat after hysterectomy and following distention of the uterus by wax pellets is discussed.

It is suggested that in women with underdeveloped uteri a condition of relative hyperestrinism may result from the sparing of estrogenic hormone, causing a block in the pituitary-ovary relationship by suppression of the gonadotropic activity of the hypophysis.

#### CONCLUSIONS

Estrogenic hormone is spared by removal of the uterus. The prolongation of the life of the corpora lutea by hysterectomy in the rabbit is a manifestation of the sparing of estrogen produced in the organism.

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# EDITORIALS

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## SURGERY Gynecology and Obstetrics

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1905-1935

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SEPTEMBER, 1942

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## PRACTICAL CONSIDERATIONS OF OVARIAN TUMORS

THE range of variety exhibited by the diverse types of ovarian neoplasms makes for difficulty in the surgical handling of these lesions. For the surgeon who has facilities for immediate diagnosis by means of the fresh-frozen section technique, this difficulty is obviated, more or less, but where such facilities are not available gross identification becomes a matter of paramount importance. The following observations may serve as useful generalizations in determination of the type of surgical treatment to be employed in individual cases.

Eighty per cent of ovarian tumors are cystic, and the majority of these are benign. Twenty per cent are solid, and approximately two-thirds of these are malignant.

Simple cysts usually are small and frequently are bilateral, are smooth of surface and never contain papillary excrescences. The lutein type of cyst will reveal a thin yellowish line on inner surface of its capsule.

Endometriomas are perforating cysts and adhere to neighboring structures. They possess a tarry content and are accompanied by punctate bluish-black nodules on the pelvic peritoneum. Conservative treatment may sometimes be employed provided complete destruction of ovarian tissue has not occurred.

Eighty per cent of cystadenomas appear as unilateral, unilocular, or multilocular cysts with thin semitransparent walls. Usually larger than simple cysts, they possess, like the aforementioned, smooth capsules free from superficial excrescences. Whenever possible, however, they should be removed intact to obviate two dangers: namely, soiling of the peritoneum by mucoid contents (60 per cent) and peritoneal seeding from "concealed" intracystic papillary carcinoma.

Fibrous papillary cystadenoma (intracystic and extracystic papillary fibroma) may occur as a unilateral or a bilateral ovarian cyst, or it may be primary in the parovarium. Usually unilocular, it possesses intracystic or extracystic hard, white, warty excrescences. Although papillary carcinoma sometimes is associated with this lesion, the combination is unusual and can be detected by a softer consistency and more luxuriant villous growth of malignant portion. In the benign papillary form peritoneal "implants" are not observed.

Dermoids may be readily recognized by their somewhat yellowish color and their opacity. Here again the surgeon should avoid rupture whenever possible, because the oily contents are highly irritative, eliciting a "granulomatous" type of peritoneal reaction. Malignancy in a dermoid can be detected upon the opening of the cyst. Dermoids are bilateral in 10 to 15 per cent of cases and in-

nocent appearing cysts on the contralateral ovary should be diagnostically aspirated. It is sometimes possible to shell out a small dermoid and thus preserve a remnant of functioning ovarian tissue.

A papillary cystadenocarcinoma is characterized by intracystic and extracystic delicate frond like excrescences. Bilateral in 35 per cent of cases particularly in its extracystic form, the lesion is associated with peritoneal implants and with ascites. However in the absence of massive metastatic 'caking' of the omentum "almost-miracles" can be wrought by removal of the primary neoplasm, with hysterectomy. This happy result occurs after removal of lesions principally of grade 1 (Broders) but occasionally of higher grade and postoperative roentgen therapy is used.

In the more undifferentiated forms of cyst adenocarcinoma, simple papillary excrescences are replaced by solid nodules of tumor tissue. These nodules may appear on the inside of an intact capsule or may present themselves in the form of superficial bosselations. Bilateral-ity is a feature in about 40 per cent and solid 'caking' of the omentum raises the important question of operability. In such cases metastasis will be found in the uterine cavity very frequently. This type forms the connecting link between cystic and solid carcinomas.

Ovarian fibroma is a solid or solid-cystic neoplasm unilateral in most of the observed instances. The shiny smooth surface, pure white color and extreme density on section are diagnostic features. Ascites frequently and hydrothorax occasionally are noted when large specimens are present. Failure to keep this fact in mind may result in denying patients the benefit of surgical exploration for a tumor that is practically always benign.

Primary solid ovarian carcinoma is bilateral in 50 per cent of cases and frequently is inoperable because of local extension or distant

metastasis. Removal is often possible when the lesion is encapsulated, but even in this circumstance recurrence is common. Necrosis, hemorrhage, local adhesions and nodular superficial projections are unfavorable features especially in large soft tumors of this type. The grade of the lesion is usually high, the primary operative mortality rate is considerable and the five year survival rate is less than 30 per cent. When unilateral, firm encapsulated lesions of lower grade are present, prognosis is, in general, good.

If the patient is an adolescent if the tumor is unilateral encapsulated, and of brittle consistency. It probably is a dysgermoma. An infantile uterus is confirmatory evidence of this. Because this tumor does not tend to spread rapidly and as it is very radiosensitive, surprisingly good results can be had even after local removal of the lesion. It represents the paradox of a grade 4 malignant neoplasm which is accompanied by a good prognosis.

Granulosa cell tumor often can be diagnosed on the basis of the clinical history. Sixty per cent occur among women who have passed the menopause, and recurrent periodic "menstruation-like" bleeding is characteristic. The tumor is unilateral solid and encapsulated, with a cut surface which has the color and consistency of liver sausage. The uterus usually is two to four times normal size. Prognosis is good. Although conservative surgery may not be so important among older women who have this tumor the importance of preservation of the contralateral ovary becomes paramount in the young, for if it is not removed pregnancy becomes possible.

Theca cell tumor is associated with a clinical history similar to that of tumors of the granulosa cell group. The neoplasm is solid and resembles fibroma. A yellow color on the surface and on section makes possible a gross diagnosis. It usually is benign.

Finally, mention should be made of metastatic tumors. If the lesion is bilateral, solid and encapsulated, if it is nodular on the surface and maintains the general contour of the ovary, if the cut section is of "rubbery" consistency and "retracts," then search should be made for a primary lesion in the gastrointestinal tract. When these metastatic lesions are present twisting of the ovarian pedicle may occur and the tumors therefore should be removed. Hysterectomy, however, is in this particular instance a useless procedure, because the ultimate outlook is, unfortunately, hopeless.

Sir Benjamin Brodie has wisely said, "When we know not what to do it is best that we do nothing." Perhaps, however, "what to do" about ovarian tumors may become more apparent through judicious evaluation of these simple rules of diagnosis.

MALCOLM B. DOCKERTY

### PHYSIOPATHOLOGICAL SIMILARITIES OF SHOCK SYNDROME IN PREPERFORA- TIVE APPENDICITIS AND CUTANEOUS BURN

THE peritoneum is approximately one-one-hundredth the thickness of the skin and is sparsely supplied with blood vessels, nerves and lymphatics, while the skin is abundantly supplied. The total surface of the parietal and visceral peritoneum and that of the skin are approximately the same. Both are composed of epithelial and connective tissue cells, in both, healing follows partial devitalization by replacement of these cells, both the peritoneum and skin protect vital inner structures, both act as barriers to bacterial invasion, both are normally moist to prevent or reduce surface friction, and, both absorb and secrete

Subclinical peritoneal shock is so designated because, preceding clinical manifestations, evidence of the shock syndrome is to be found by chemical analysis of the blood. Hemoconcentration and diminished plasma and blood volume precede and accompany these clinical manifestations. Occasional cases of preperforative appendicitis produce this type of shock. Clinical peritoneal shock is present during the terminal phases of a spreading peritonitis. It may be masked by the symptoms and signs accompanying the pathological changes which are frequently sudden in onset, as in the case of acute perforation of a duodenal ulcer or an acute pancreatitis.

Erythema, widening and prolongation of capillary and lymph vessels, extravasation of plasma into cavities and tissue spaces with associated hemoconcentration, and hypoproteinemia, followed by diminished red cell volume, occur in patients with preperforative appendicitis and cutaneous burns of moderate degree. In the peritoneum, the gross changes are not as evident as in the skin where the injury induced by the heat causes dilation of the capillaries with increased exudation of plasma through the capillary walls. The cause of the dilatation of the capillaries in the peritoneum is the action of bacterial toxins but the end-result, increased capillary permeability, is identical. The loss of plasma accompanying burns is external and interstitial. In preperforative appendicitis, the fluid leaks into the peritoneal cavity, into the preperitoneal, parietal, and visceral peritoneal tissue spaces and into the deeper coats of the intestine or stomach adjacent to the lesion.

The extravasation of plasma in burns occurs immediately and attains its maximum in point of time and amount in from 36 to 40 hours, in preperforative appendicitis in man and in the preperforative induced gangrenous appendix in the dog, we have collected plasma in

amounts sufficient to be analyzed for proteins within a period of 2 hours. The amount of plasma loss in burns varies with the extent and severity of the lesion.

In 1930 Underhill Kapsinow and Fish estimated from experiments on rabbits that a man weighing 65 kilograms who has sustained a superficial burn involving one sixth of his body surface will have lost 70 per cent of his plasma within the first 24 to 36 hours a total of 3,500 cubic centimeters. If one-third of the body surface were involved 7,000 cubic centimeters, the limit to which the organism may give up its reserve water if it is to maintain blood volume constant. Estimations of the amount of plasma which leaks from the blood vessels into the peritoneal cavity and tissue spaces are not so definite. In one patient with preperforative gangrenous appendicitis—male weight 50 kilograms—400 cubic centimeters of plasma were estimated to have been present in the peritoneal cavity. No attempt was made to judge the apparently large amount of fluid lost in the preperitoneal, parietal, and visceral peritoneal tissue spaces.

Chemical examinations of the fluid which extravasates from the blood following burns and into the peritoneal cavity in preperforative appendicitis show that the proteins and electrolytes are approximately the same. In 1930 McIver analyzed blister fluid and found total proteins to be 3.7 per 100 cubic centimeters and chlorides 59. We have just reported that the protein content of the peritoneal exudate in preperforative appendicitis is approximately the same as blood plasma and that apparently a relationship exists between the type of the pathological lesion and the albumin-globulin content of the blood plasma. We have also demonstrated that the plasma chloride level in preperforative appendicitis is adequately maintained. In 1930 Underhill observed that in burns as much as

36 per cent of the sodium chloride of the blood may be lost without causing alteration in the chloride content of the blood.

In both superficial cutaneous burns and in the peritoneal changes secondary to preperforative appendicitis in man and induced gangrenous appendix in dogs, reabsorption of plasma occurs. Underhill has shown that while in the early stages of a burn the oil changes in the capillary permit the extravasation of plasma, reabsorption into the capillary does not occur until approximately the fortieth hour. Our observation in dogs show that as the localizing process (an early appendiceal perforation walled off by a fibrous exudate ofherent loops of intestine or omentum) progresses toward the stage of abscess formation the amount of peritoneal exudate diminishes. This occurs usually 48 hours after ligation of the appendix. It will be of importance to determine what effect this reabsorption has on total circulatory protein content of blood.

Thus, while there are some anatomical structural differences in the peritoneum and skin, numerous close similarities may be noted. Subclinical shock (hemoconcentration, fall in plasma and blood volume decrease in amount of circulating protein) occurs in both preperforative appendicitis in man and induced gangrene of the appendix in dogs and in superficial burns in man. Increased permeability of capillaries occurs in both preperforative appendicitis and in cutaneous burns in both man and the dog. The time of appearance of plasma in the interstitial spaces and in the peritoneal cavity, the amount of plasma loss, the protein and electrolytic content, and the phenomenon of reabsorption of plasma in shock due to retraction of the peritoneum to preperforative appendicitis in man and induced gangrene in the dog and to superficial cutaneous burns in man are all similar.

JOHN O. BOWEN

J. G. REYNOLDS

# THE SURGEON'S LIBRARY

## REVIEWS OF NEW BOOKS

A BRILL book, *Subacute Bacterial Endocarditis*,<sup>1</sup> is presented by Emanuel Libman and Charles R. Friedberg and edited by Henry A. Christian.

In the foreword Henry A. Christian states that recent advances in chemotherapy have made possible a new therapy of many infectious diseases but for many of them the results remain far from satisfactory. He commends this volume to the reading medical public because of the need for early diagnosis of subacute bacterial endocarditis if more effective therapy is to be possible.

The authors, eminent authorities with life long interest in the disease, have drawn from the wealth of their personal experience and the world literature to present a complete, well balanced study of a difficult subject.

In the classification of bacterial endocarditis they prefer the term subacute even in cases lasting a year or more, because these prolonged cases are not really chronic in the sense of glomerulonephritis, tuberculosis, or valvular heart disease. They recognize it as a common disease and one of them (I. L.) observed personally 1000 cases from 1890 to 1930.

In a brief but concise discussion of etiology they state that in over 90 per cent of the cases the causative organisms are nonhemolytic streptococci, usually of the alpha (viridans) variety. As a rule it is the patients with valvular defects who have few or no symptoms, who are most subject to the disease. The symptoms of the disease are thoroughly discussed and special attention given to those which appear after "grippal" infections, operative procedure, pregnancy and puerperium, but it is often not possible to say whether these associations are merely coincidental or causative.

Eleven pages with 7 excellent illustrations are given to the essential discussion of pathology. The fact is stressed that the fundamental feature of the disease is the presence of bacterial vegetations on the heart valves which contain bacteria and are readily washed off into the blood stream giving rise to the bacteremia, toxemia, and the occurrence of embolic phenomena.

The symptom complex arises from the endocardial involvement or its complications. The early combination of symptoms is such as to simulate a variety of diseases with resulting confusion and the authors have given close attention to the general signs and

symptoms with special reference to the involvement of individual organs.

The recognition of mild cases and the differentiation between the "bacteria free stage" and "recovery" are emphasized. These terms are arbitrary and were introduced by one of the authors (I. L.) some years ago. Their concept is completely expressed in 18 pages with 7 illustrations.

In the general discussion of prognosis, the authors state that they have personally observed at least 25 cases of spontaneous recovery. Twelve of these are reported in detail and are called recovered cases. They recommend that prophylaxis be directed particularly to cases in which there is a valve lesion causing no or but trifling discomfort. All infection should be avoided, eliminated if present, and one of the new chemotherapeutic agents should be administered before and after surgical procedure.

The authors discuss all of the acceptable forms of treatment and conclude that while therapy remains unsatisfactory chemotherapy, particularly the use of sulfapyridine, seems to offer the greatest promise of cure. The importance of general supportive measures, early blood transfusion, and the need for a more effective chemotherapeutic agent are emphasized. This volume is easy to read, interesting, and complete. It is a valuable asset in any medical library but especially to the student of medicine and the busy practitioner.

GEORGE C. TURNELL

THIS volume of 597 pages by Dr. Kugelmass on *Blood Disorders in Children*<sup>1</sup> indicates somewhat the vast amount of material that has accumulated in this field. The book was written for practitioners and pediatricians to help solve blood problems seen in everyday practice in sick children. The order of the various sections of the book are as follows: (1) the hemopoietic system embracing the blood and blood forming organs in health and disease, (2) the erythron embodying the normal red cell mechanism, the anemias, polycythemias and pigment disorders, (3) the leucon comprising the normal white cell mechanism, the myeloid, lymphoid, and monocytic disorders, and the leucemias, (4) the thrombin covering the normal clotting mechanism and the essential and vascular hemorrhagic disorders, (5) the reticuloendothelial system including the normal mechanism and congenital lipidoses, (6) finally the blood picture characteristic of systemic and infectious diseases.

<sup>1</sup>BLOOD DISORDERS IN CHILDREN. By J. Newton Kugelmass, M.D., Ph.D., Sc.D. (Hon.). London, New York, and Toronto: Oxford University Press, 1941.

<sup>1</sup>SUBACUTE BACTERIAL ENDOCARDITIS. By Emanuel Libman, M.D., and Charles R. Friedberg. Edited by Henry A. Christian, A.M., M.D., LL.D., Sc.D. (Hon.), F.A.C.P., Hon. F.R.C.P. (Can.). (Reprinted from Oxford Loose Leaf Medicine). London, New York, and Toronto: Oxford University Press, 1941.



The brief historical outlines preceding each chapter are interesting and useful. At the end of the book are a blood glossary and an outline of symptom diagnosis.

The book is published on glossy paper and the format makes for easy reading. The book is written in an extremely general manner. There are few specific references to the source of material in the body of the text. A few key references are added at the end of each chapter. Because of frequent repetition in certain sections, the size of the book could probably be reduced considerably. Numerous statements presented factually are still controversial in the field of hematology, e.g. the presence of splenic hormone, the relation of so-called vitamin P to vascular purpura in man, the use of diet for increasing the clotting time of the blood, etc.

The illustration of blood cells on page 9 is the same as that in Whitby and Britton, *Diagnosis of the Blood*, but no acknowledgment of the source is given.

The classification of the anemia under the headings, deficiency, dyspoietic, hemolytic and hemorrhagic, is simple and practical. The sections on hemolytic anemia and hemorrhagic diseases are especially comprehensive. Representative case histories illustrate many aspects of the various blood disorders.

It is questionable whether there is definite need for a book of this type. Most of the information needed by the practitioner can be obtained from a good general text on hematology. The pediatrician will probably find the volume useful as a reference source.

HAROLD L. GIL

## CORRESPONDENCE

### THE GENERAL SURGEON'S APPROACH TO THE PROBLEMS PRESENTED BY FRACTURES AND OTHER TRAUMA

To the Editor: The following letter was recently received by me:

From the office of Surgeon Rear Admiral Cecil P. O. Wakeley  
Royal Naval Hospital  
Hendler, Newport  
Rhode Island  
16th May 44

Dear Professor Lee:

"I have read with great interest your article on 'The General Surgeon's approach to the problems presented by Fractures and other Trauma' which was published in *Surgery, Gynecology and Obstetrics* in February of this year.

Your Figure showing 'Wound of face resulting from high explosive bombs' was a case of mine and I notice that you put 'By courtesy of Mr. Broster'.

"When Mr. Broster sent to America last year he asked me for some pictures of wounds as he was giving a paper in America.

This paper has since been published in the *Annals of Surgery* where due credit was given to me for my pictures, now I see that Mr. Broster is credited with them.

As these pictures are likely to be published further here here I should like to point out that the copyright must not be given to Broster.

I hope you will excuse me pointing out this to you but simply to prevent controversy at a later date.

With all good wishes,

Yours sincerely

(Signed) CECEL P. O. WAKELEY

I am sorry that I had forgotten that this photograph had been borrowed by Mr. Broster from Mr. Wakeley. Credit for the illustration should be given Mr. Wakeley.

WALTER ESTELL LEE

Philadelphia,  
Pennsylvania.

# CLINICAL CONGRESS OF AMERICAN COLLEGE OF SURGEONS

W EDWARD GALLIE, Toronto, *President*

IRVIN ABELL, Louisville, *President-Elect*

*Committee on Arrangements*

THOMAS E JONES, *Chairman*, JOHN W HOLLOWAY, *Secretary*

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## 1942 CLINICAL CONGRESS IN CLEVELAND—A WAR SESSION

AS the Stevens Hotel in Chicago has been taken over by the Army for its Air Corps Training School, it was necessary to make a change in the plans for the 1942 Clinical Congress. The date and place of the 1942 session have been changed to November 17-20, in Cleveland, with headquarters at the Cleveland Public Auditorium, which provides exceptional facilities, so that all activities of the Congress, excepting the clinical program, will be located in that building.

Under the direction of the Board of Regents a four-day program is being developed for the thirty-second annual Clinical Congress, which will be based upon the many medical and surgical problems that arise out of the prosecution of an all out effort to win the war, emphasizing the needs of the rapidly expanding medical services of the Army and Navy and consideration of the special problems related to the increasing activities for civilian defense. These subjects will highlight the programs for the scientific sessions at headquarters and will provide the basis for many clinical demonstrations at the hospitals.

### CLINICAL PROGRAM

The surgeons of Cleveland have organized with Dr. Thomas E. Jones as chairman and Dr. John W. Holloway as secretary of the Committee on Arrangements. The committee plans to present a program of operative clinics and demonstrations that will provide a comprehensive showing of their clinical activities in all departments of surgery at the Western Reserve University School of Medicine and the approved hospitals of Cleveland. Under the leadership of this committee, representative of the interests of all surgical specialties, a complete and varied program is assured for all who attend the Congress. The four day program

### EXECUTIVE COMMITTEE

Thomas E. Jones, Chairman  
John W. Holloway, Secretary  
Arthur H. Bill  
Abram B. Bruner  
John F. Corrigan  
Clarence W. Engler  
Samuel O. Freedlander

C. Lee Graber  
John E. Hannibal  
Carl H. Lenhart  
Thomas P. Shupe  
Abraham Strauss  
Oliver A. Weber  
Theodore A. Willis

will include a presentation of the latest advances in diagnostic methods, surgical technique, operative procedures, pre- and postoperative care of the surgical patient. A preliminary clinical program is being prepared at the direction of the Committee on Arrangements and will appear in the October issue of this journal and the September *Bulletin* of the College. It is to be noted that clinics and demonstrations will be held in the hospitals on the afternoon of Tuesday, November 17, and the mornings and afternoons of succeeding days.

The clinical programs at the hospitals will be arranged to include a wide variety of subjects in general surgery, obstetrics and gynecology, fractures and other traumas, neurosurgery, thoracic surgery, orthopedic surgery, urology, ophthalmology and otorhinolaryngology. In the final program the presentations under these classifications will be so correlated that the visiting surgeon may devote his time to those clinics dealing with the special subjects in which he is most interested. During the Congress the complete detailed clinical program for each day will be posted in the form of bulletins at headquarters during the afternoon of the preceding day and distributed in printed form each morning.

### GENERAL ASSEMBLY

The opening session of the Congress, at 9:30 on Tuesday morning, will be a general assembly at headquarters for surgeons, hospital representa-

tives, and others. Dr. Irvin Abell, Chairman of the Board of Regents, will present a report on the field activities of the College including the official announcement of the approved lists of hospitals, cancer clinics, hospitals approved for graduate training in surgery, and the surgical specialties, medical services in industry, and medical motion pictures. Dr. W. Edward Gulhe, of Toronto, President of the College, will speak on "Medical and Hospital Service in the War." The program for this session includes the following:

Major General James C. Magee, Surgeon General, United States Army: Army Medical Service in the War  
Rear Admiral Ross T. McIntire, Surgeon General, United States Navy: Naval Medical Service in the War  
Thomas Parran, M.D., Surgeon General, United States Public Health Service: "The Health of the Nation in Wartime"  
Colonel George Baehr, Chief Medical Officer, Office of Civilian Defense: "Civilian Defense in Its Relation to Medical and Hospital Service"  
Frank H. Lahey, M.D., Chairman of Directing Board, Procurement and Assignment Service: "The Procurement and Assignment Service"

#### PRESIDENTIAL MEETING AND CONVOCATION

At the Presidential Meeting and Convocation, on Tuesday evening, 1815 in the Music Hall of the Cleveland Public Auditorium, the new officers of the College will be inaugurated, and the 1934 class of initiates received into fellowship. Distinguished surgeons from foreign countries attending the Congress will be introduced following which the presidential address will be delivered by Dr. W. Edward Gulhe of Toronto. The new officers are:

Irvin Abell, M.D., Louisville, President.  
Leland S. McKitterick, M.D., Boston, First Vice President.  
F. Phinley Calhoun, M.D., Atlanta, Second Vice President.

Participating in the program for this session are the following:

Major General James C. Magee, Surgeon General, United States Army.  
Rear Admiral Ross T. McIntire, Surgeon General, United States Navy.  
Thomas Parran, M.D., Surgeon General, United States Public Health Service.  
Colonel George Baehr, Chief Medical Officer, Office of Civilian Defense.

#### PANEL DISCUSSIONS ON WAR SURGERY

The value of the panel discussion as a medium of conveying information on selected subjects has been amply demonstrated at previous sessions of the Congress sectional meetings, and the "War Sessions," that were held throughout the country during the early part of the present year. The Board of Regents has deemed it wise to use this medium as the principal method for the presenta-

tion of subject. At the 1943 Clinical Congress, Master panels have been planned for each afternoon, Tuesday through Friday, and on Wednesday, Thursday, and Friday evenings.

The restriction of the program to subjects dealing, for the most part, directly with surgery has made it desirable to arrange these panel discussions so that they will be held consecutively rather than asynchronously. This arrangement will enable surgeons attending the Congress to be present at each of the panel discussions, all of which will be held in the Cleveland Public Auditorium, which affords ample accommodations.

Surgeons who are in active military medical service will be among the speakers and collaborators in all of the panel discussions. Other eminent surgeons will also participate and questions from the floor will be welcomed. A few of the subjects and the leaders of discussions are as follows:

Shock, Blood and Blood Substitutes, Burns, and Combating Chemical Warfare—Alfred Blalock, M.D., Baltimore  
Wounds in General—Ulen O. Whipple, M.D., New York  
Wounds of the Chest—Ernest A. Graham, M.D., St. Louis  
War Injuries to the Skull—Howard C. Kallier, M.D., San Francisco  
War Injuries to the Face—Robert H. Ivy, M.D., Philadelphia  
Amputations—Ralph T. Knight, M.D., Minneapolis  
Fractures—Lieutenant Colonel Robert H. Kennedy, M.C., U.S.A., Washington

Transportation of the wounded and their treatment at the various types of hospitals and stations established by the military services as well as aboard airplanes and ships, by the medical corps of the Army and Navy will be the featured subject at another master panel.

On Wednesday evening, in addition to the panel discussions, the annual oration on surgery will be delivered by Captain Frederick R. Hood, M.C., U.S.A., Washington on the subject of "Wounds in Combat." The following symposium will be presented on the same evening:

Pertussis—Aspects of Tropical Diseases, Captain Charles S. Stephenson, M.C., U.S.A., Washington  
Prevention of Acute Infectious Diseases, Colonel Hugh J. Morgan, M.C., U.S.A., Washington  
Venereal Disease—Lieutenant Colonel T. B. Turner, M.C., U.S.A., Washington  
Gynecology and Obstetrics in Their Relation to the War—J. Rayburn Miller, M.D., Hartford, Conn.

#### FORUMS ON FUNDAMENTAL SURGICAL PROBLEMS

The Forums on Fundamental Surgical Problems, introduced with outstanding success at the 1941 Clinical Congress in Boston, will again have an important place on the program. Under the

chairmanship of Dr Owen H. Wangensteen, of the University of Minnesota, a committee is formulating plans in detail. Through this forum, which will be held on Wednesday, Thursday and Friday mornings, an opportunity will be given the younger men, representing various university departments of surgery, to present the important results of their clinical and experimental research work before a large surgical meeting. Heretofore these younger men have seldom been able to present their original work and ideas, since many of them have not yet qualified for membership in the principal surgical societies.

Surgery today is concerned not only with anatomy and pathology, but to a growing extent with physiology, chemistry, and physics. Hence it is felt that the presentation of selected material of this type broadens the Clinical Congress program and is of great benefit to the surgeons attending the sessions.

No prepared discussions are planned but opportunity to ask questions will be afforded. Ten minutes is allotted to each presentation. Some of the best examples of new and highly constructive developments in surgery are expected to be presented in these Forums.

#### SURGERY OF THE EYE, EAR, NOSE AND THROAT

Operative clinics and demonstrations in surgery of the eye, ear, nose and throat will be given daily at the hospitals. In addition, the general program of the Clinical Congress includes many features of special interest to those surgeons whose practice is limited to ophthalmology and otorhinolaryngology. Also planned for this group are a series of clinical conferences on Wednesday, Thursday, and Friday mornings at headquarters. In these conferences subjects of timely interest to specialists in these fields, will be discussed in small groups. Outstanding men will lead the discussions and opportunity will be provided for questions and participation.

Programs are being prepared for panel discussions on Wednesday, Thursday, and Friday evenings. Preceding each morning and evening session, selected motion picture films on subjects related to these special fields will be exhibited.

#### HOSPITAL STANDARDIZATION CONFERENCE

The twenty-fifth annual Hospital Standardization Conference will open at 9:30 on Tuesday morning, in the Cleveland Public Auditorium, with a general assembly of surgeons, hospital representatives and others, the program for which appears on a preceding page. In his opening address, Dr. Irvin Abell, Chairman of the Board of Re-

gents, will summarize the results of a quarter of a century of work in this department, and will officially announce the 1942 list of approved hospitals, hospitals approved for graduate training in surgery, and approved cancer clinics.

The subjects to be discussed at the Tuesday afternoon session have to do with adjusting hospital administration and services to present war conditions, maintaining essential man power in civilian hospitals, the needs of the armed forces for medical and nursing personnel, and include a special report on what has been accomplished in the Canadian hospitals in respect to these problems.

A series of panel discussions is planned which are to be centered around a general theme, with discussion of various aspects by well-known authorities. One panel will deal with the newer procedures in therapies developed during the war. Other panels will deal with shock, flesh wounds, burns, fractures, head and chest injuries, and their administrative or service significance. The problem of maintaining standards of service for medical staff conferences, pathological, x-ray, and anesthesia services will be discussed in another panel. Under the title of "Responsibility of the Administrative Staff in Dealing with Common Emergency Procedures," the subjects to be presented include post-tonsillectomy hemorrhage, respiratory obstruction, sudden collapse of postoperative patient due to pulmonary embolus, respiratory failure, acute cardiac attack (coronary thrombosis), sudden collapse on operating table, hemorrhage (acute and postpartum), and acute poisoning. The problem of maintaining adequate medical records in civilian hospitals will be the subject of another panel. Participating in these panels will be surgeons, surgical specialists, pathologists, anesthesiologists, and hospital administrators. The program will include especially arranged group conferences and demonstrations in selected hospitals, open forums and round-table conferences, and the showing of motion pictures of especial interest to hospital personnel. The aim is to provide features of interest to all types of hospital workers, administrators, department heads, personnel, members of the medical staffs, and governing boards.

Sustained interest in the College program of graduate training in surgery and the surgical specialties has been evidenced by the majority of hospitals suitable for such training. Opportunities will be provided for the discussion of individual problems. Many reports have been received showing that strenuous efforts are being made by most hospitals to preserve the essential features of their program despite the loss of men

for war service. Representatives of hospitals will be invited to discuss their plans for maintaining the College program, with a view to its adaptation to postwar needs. It is to be noted that the master panel on Friday afternoon, dealing with transportation of the wounded mentioned on a previous page will be a joint session for surgeons and hospital personnel and will afford an excellent opportunity for hospital representatives to hear directly from the officers of the medical corps of the Army and the Navy concerning the various types of hospitals and stations that have been established both on land and on ships.

#### CANCER CONFERENCE

A cancer conference sponsored by the Cancer Committee of the College, will be held on Thursday morning. The subjects to be discussed will be those which are of immediate interest, indicating new lines of research, methods of attacking the cancer problem, and results obtained. Some methods of organization in cancer control will also be presented.

#### SURGICAL MOTION PICTURES

Daily presentation at headquarters of a large and varied program of surgical motion pictures is planned. The latest available films, on a wide variety of subjects of interest to the surgeon, will be included. Both sound and silent, standard and color films, that have been approved by the Committee on Medical Motion Pictures will be shown.

#### ADVANCE REGISTRATION AND REGISTRATION FEES

The hospitals and medical school of Cleveland afford accommodations for a large number of visiting surgeons, but attendance must be limited at the clinics to the number that can be comfortably accommodated. It is expected therefore that surgeons who wish to attend the Congress will register in advance. As in previous years, admission to clinics and demonstrations in the hospitals and to certain of the scientific meetings at headquarters will be controlled by means of tickets issued to the visiting surgeons on application at the registration desk. This plan provides for the distribution of visitors and helps to insure against overcrowding. Visiting surgeons are urged to cooperate in making the clinic ticket plan a success.

In accordance with a resolution adopted by the Board of Regents, fellows of the College whose dues are paid to December 3, 1941 initiates of the class of 1941 and fellows in military service will not be required to pay a registration fee for

the 1942 Clinical Congress. For colored ~~joint~~ candidates the fee is \$5.00. Surgeons, not fellows, who attend as invited guests of the College will pay a registration fee of \$10.00.

For purposes of identification at the registration desk, fellows should present their fellowship card. Those surgeons who pay the registration fee in advance will receive a formal receipt which they will exchange for a general admission card upon presentation at the registration desk in the Cleveland Public Auditorium.

#### HEADQUARTERS—TECHNICAL EXHIBITION

Headquarters for the Congress will be established at the Cleveland Public Auditorium, which affords unusual facilities for accommodating the Congress. All activities except the clinics at the hospitals will be held in this building.

The Technical Exhibition, together with its registration and clinic ticket desk, will be located in the arena on the main floor of the Auditorium. The daily clinical program, in the form of lectures, will be posted there. Leading manufacturers of surgical instruments and supplies, sutures, dressings, pharmaceuticals, operating room equipment, x-ray apparatus and hospital equipment of all kinds, as well as publishers of medical books will be represented in the exhibition. An opportunity for careful inspection of the latest products of these industries which are aiding the work of the surgeon and the hospital, will be provided for the visiting surgeons and hospital personnel.

#### CLEVELAND HOTELS AND THEIR RATES

Cleveland has many first-class hotels, several within walking distance of the Public Auditorium, providing ample hotel facilities at reasonable rates. It is suggested that reservation of hotel accommodations be made at an early date. The following hotels are recommended by the Committee

	Minimum rate with tax Breakfast Dinner
Allerton, Chester, 1 East 5th St.	\$2.50 \$4.00
Auditorium, St. Clair at East 6th St.	.00 1.00
Carter, Prospect at East 9th St.	3.00 4.50
Cleveland, Public Square	3.00 4.50
Hollenden, 610 Superior A. N. E.	3.00 4.50
Lake Shore, 500 Edgewater Ave.	.00 3.00
New Amsterdam, Euclid at East 22nd St.	.00 3.00
Olmsted, Superior at East 9th St.	.00 4.00
Sovereign, East Blvd and East 5th St.	3.00 4.00
Statler, Euclid at East 7th St.	3.00 4.50
Tudor Arms, 6600 Carnegie A.	3.50 5.00
Wade Park Manor, Park Lane at East 107th St.	3.50 5.00

# SURGERY

## GYNECOLOGY AND OBSTETRICS

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### TRAUMATIC SHOCK—A CONSIDERATION OF SEVERAL TYPES OF INJURIES

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IN all types of diseases and injuries the ideals to be sought for are early diagnosis and effective therapy. A number of factors militate against the accomplishment of these objectives in dealing with the conglomeration of abnormalities which are grouped together under the term shock. Even those instances of failure of the peripheral circulation about which we know a great deal, such as that which may follow simple hemorrhage, become complicated when considered together with many other types, some of which may have no relation whatever to each other. It might be wise if the word "shock" could be abolished, but common usage makes this impossible at the present time. Since the word will probably be retained, it would be helpful if a descriptive term could be used with it such as shock following hemorrhage, shock following burns, shock following trauma to large masses of muscle, shock following crush injuries, postoperative shock, and so forth.

Many efforts have been made to find a uniform means of diagnosing early or incipient shock. Again, the problem is complicated by the all-inclusive use of the word shock. It will be very surprising if a constant early diagnos-

tic alteration which is common to all types is found. The most likely possibility lies in the detection of a diminution in the whole blood or plasma volumes in the traumatic type of shock, and these determinations have not yet been perfected to the extent that they are practical under most emergency conditions. The finding of hemoconcentration is of value in those instances such as burns, in which the fluid which is lost is plasma rather than whole blood, but it is not the usual early observation when red blood corpuscles as well as plasma are lost. At any rate, efforts which are directed toward the determination of the early alterations should continue, for it is generally agreed that significant alterations of the systolic blood pressure may be a late finding.

Discussion in this paper will be limited to a consideration of four types of injuries, namely, blast, burns, crush injuries, and trauma to large masses of muscle. Careful clinical studies are few in number, and it is for this reason that much of the discussion will deal with experimental observations.

#### BLAST

Except for the observations of Hooker on the effects of blast on the arterial and venous pressures, little was known about the nature of injury until the present war. The British have reported a number of cases in which

From the Department of Surgery of the Johns Hopkins University and Hospital.  
The Donald C. Balfour Lecture delivered at the University of Toronto, May 1941.  
Dr. Duncan, William Stewart Halsted Fellow in Surgery.

death was produced by blast, even though there was no sign of injury to any external part of the body. A number of recent experimental studies have been performed on this condition and notable among these are those of Zuckerman and his associates (17). They performed a series of experiments in which rabbits' trunks were protected while their heads were directly exposed to high blast pressures, and it was found that the thoracic and abdominal lesions which result from blast are due to the wave acting on the surface of the body and not to either the pressure or the suction components of the wave acting through the nose and mouth. They conclude that the thoracic and abdominal lesions are primarily due to the impact of the pressure component on the body wall and that the lesions can occur when the suction component is excluded. It is found that in animals exposed to high blast pressures, concussion does not occur. There are a number of ways in which blast may cause death. Immediate death unassociated with external trauma in some instances is due to occlusion of the larger bronchi by blood clot. Delayed death is due usually to pulmonary edema, and less often to intraperitoneal hemorrhage.

The experimental studies coincide very closely with the clinical observations in that intrapulmonary hemorrhage is the most frequent finding. This is at least one condition in which the intravenous administration of large quantities of blood and blood substitutes seems to be contraindicated. The use of oxygen and morphine is indicated. The induction of general anesthesia is contraindicated.

#### BURNS

It has been often stated that this is a "burn-war" and it is rather generally agreed that at the present time there is no one type of injury that is more important or more frequent. Underhill Blalock (4) and others have shown that burns result in the local escape of plasma from the blood stream. In 1931 one of us (A.B., 4) stated "It is impossible to escape the fact that the loss of such large amounts of whole plasma into the burned area must play an important part in causing a reduction in the blood pressure as a result of the diminu-

tion in the blood volume. Regardless of whether or not death is due solely to loss of plasma, the present experiments indicate that the fluid loss probably is the initiating factor in the decline in blood pressure. After the blood volume is reduced and the blood is very concentrated, it is likely that toxins, if present even in small amounts, will exert deleterious effects since elimination by the kidney is greatly reduced. In the human being, the factor of loss of fluid after burns may be even more important than in the dog since there is copious weeping from the injured skin in man, and this is not encountered in dogs. It is entirely possible that such agencies as lactic acid and epinephrin exert their beneficial effects by preventing loss of fluid rather than by stopping the absorption of toxins. These results have been confirmed and amplified by Harkins and others. Most of the experiments have been of relatively short duration and the results do not exclude the possibility of the deleterious effects of slowly acting decomposition products. Longer experiments are complicated by the necessity of continuous anesthesia.

Approximately 80 per cent of deaths which are due to burns occur within the first 2 days. It is in the early stage that the local loss of plasma is such a prominent feature. Although positive proof is lacking, it is likely that infection and toxemia play an important part in the cause of deaths which occur 24 hours or later following a burn. Aldrich says that when there is no infection there is no toxemia, but there is a good deal of evidence which supports the toxemia theory. Wilson and his associates (21) found that edema fluid gradually acquires toxic products. Drinker and his associates (12) have obtained evidence recently that the lymph which is collected from a burned area exerts toxic effects on subsequent injection.

All are agreed that as a result of burns there is a great loss of plasma from the blood stream. There is some difference of opinion as to the relative rôles of local and of general loss in the cause of peripheral circulatory failure. It is our opinion that the early loss of plasma is mainly local and that the general loss occurs later. Regardless of when the loss occurs, the best means of preventing or treating the di-

ulatory failure consists of the intravenous administration of large quantities of plasma or serum. The injection of large amounts of solutions of crystalloids is contraindicated because it may result in a further depletion of plasma proteins (3). If the quantity of plasma which is available is limited, the initial injections should not be very large, since it has been shown by Rhoads, Lee and Wolff that the loss of injected plasma is more rapid during the early stages following the burn than it is subsequently. These observers have found, what was previously only an impression, that the application of tannic acid reduces the local loss of plasma.

Since it appears likely that under most circumstances blood plasma will be available for the treatment of patients with burns, the crying need is for some product which will decrease capillary permeability or for an agent which will destroy the hypothetical toxic products which return to the general circulation from the burned area. In addition, there is a need for a cheap, rapidly drying local agent with antiseptic properties which can be applied quickly. The present war will probably result in many advances in the general and local treatment of burns.

#### CRUSH INJURIES

Several articles appeared before and during the first World War in German periodicals on the effects of crush or compression injuries, and it was noted that peculiar renal lesions may occur. The condition then appears to have escaped attention until fairly recently, when the British medical literature has contained reports of a number of cases. Most of these crush injuries have occurred in association with air raids in which persons have been trapped beneath fallen debris.

The essentials of the clinical history and observations are as follows:

- 1 Compression of limb for several hours or longer
- 2 Crushed ischemic muscle
- 3 Frequently local anesthesia
- 4 Swelling of extremity, hemoconcentration
- 5 Shock, favorable response to therapy
- 6 Progressive oliguria
- 7 Urine contains albumin, brown or black granular casts. Gross blood in some cases
- 8 Uremia

- 9 Jaundice, rarely
- 10 Gangrene of injured extremity
- 11 Death in approximately two-thirds of reported cases

The autopsy findings which have been reported include the following:

- 1 Muscle necrosis
- 2 Kidneys enlarged, moist cut surface, pallor and mottling of cortex, congestion of pyramids
- 3 Homogenous masses in Bowman's capsule
- 4 Necrosis and regenerative changes in cells of 2d convoluted tubules
- 5 Increase in interstitial tissue about these tubules
- 6 Brown or black granular casts in 2d convoluted tubules
- 7 Tubulovenous lesions consisting of aneurysmal bulges in ascending limb of Henle's loop with damage to tubular epithelium and adjacent venule

The various forms of treatment which have been used or suggested include the following:

- 1 Treatment of shock
- 2 Promotion of diuresis
- 3 Alkalinization of urine
- 4 Intermittent positive pressure
- 5 Amputation (fatal result)
- 6 Multiple incisions into extremity (fatal result)
- 7 Tight bandaging of injured limb
- 8 Tourniquet with intermittent or slow release
- 9 Atropine or papaverine (relief arterial spasm)
- 10 Adrenal cortical extract

We have attempted to reproduce the condition experimentally. After the employment of several methods, such as the application of a tourniquet to the thigh and the compression of an extremity between the flat surfaces of boards, it was apparent that the degree of injury to the tissues was not sufficiently great. The method which was eventually devised consisted of compressing the thigh between uneven surfaces. This was accomplished by fixing triangular strips of wood on the inner surfaces of two boards. The strips were arranged so that their coaptation would result in an interdigitation or cog-like arrangement when the two boards were placed opposite each other on the thigh, and approximation of the boards was caused by shortening the springs which were placed at the four corners. A groove was made in the center of each of the insets of triangular strips of wood. When the press was in place these grooves corresponded to the course of the femur, and thus the greater



TABLE I.—CRUSH INJURY—5 HOURS' DURATION

Type of experiment	No. of experiments	Decline in blood pressure 4-6 hrs. after pressure removed from leg	Change hematocrit in % of control figure 4-6 hrs. after pressure removed	Survival	Average duration survival of others	Final body temp.
Control No therapy	19	30	43		17' 15"	
Pneumatic tube 12 lb. at 6 hrs.		36	38		20' 30"	3
Plasma therapy 3 1/2% body weight		23.3	20.6		30"	
See control with crush	7	30	30		21 hrs. at 3 days	
See subsequent to crush		30.0	33		17' 30"	14

\*Important findings included swelling of leg, hemoconcentration, decline in blood pressure, oliguria, abnormal urinary findings, dorsal hot crusts, emaciation.

part of the pressure was on the soft tissues of the thigh rather than on the femur. The pressure which was transmitted to the thigh was approximately 500 pounds. Medium sized animals with well developed muscles were chosen. The press was usually left in place for 5 hours. Pain was prevented by the use of nembutal and morphine. Further details are given in a previous article (9).

Nineteen control experiments were performed in which the press was applied for 5 hours, and no form of therapy was carried out after its removal. The only significant alterations which were noted during the 5 hour period were the appearance of red blood cells and albumin in the urine. The nonprotein nitrogen and plasma creatine levels increased slightly in some animals during this time, and a slight increase in urinary creatine was found in some of the animals. No significant alterations in blood pressure, pulse rate, hematocrit reading, respiratory rate, or rectal temperature were observed during this 5 hour period.

The alterations which occurred following the removal of the press were pronounced. The arterial pressure usually declined immediately and remained depressed for a few seconds before returning to or almost to the normal level. Beginning 15 to 30 minutes later there was a slowly progressive decline in arterial blood pressure until death ensued. The pressure had usually declined about 50 millimeters of mercury at the end of 4 hours after removal of the press. Progressive hemoconcentration occurred in all experiments except one. The average increase at the end of 4 hours

being 44 per cent above the control level. Gross discoloration of the urine due to blood and possibly myohemoglobin was noted at the end of 1 hour following removal of the press. Red blood cell casts and granular casts were observed in most of the experiments, but these could not be definitely identified as the large dark brown casts described in human cases. Blood and urinary chemical changes included an elevation in nonprotein nitrogen as increase in plasma creatine and creatinine levels and creatinuria. Eighteen of the 19 animals died, the average survival period being 7 hours and 33 minutes. Dissection of the posterior part of the body and comparison of the weights of the injured and noninjured sides showed an average local fluid loss into the injured area which was equal to 3.3 per cent of the total body weight. The fluid in the injured part was yellowish in color and contained very few red blood corpuscles. The findings at autopsy were in general characteristic of those observed in shock. Histological examination of the kidneys revealed areas of dilatation of the renal tubules with flattening of the epithelium but the characteristic degenerative lesions which have been described in patients were not found. Some of the results in these experiments are given in Table I and the results of one experiment are shown graphically in Figure 1.

Additional experiments have been performed with several aims in view. Shock can be produced more uniformly by the employment of this method than by any other with which we are familiar and it seemed to be de-

sirable to inquire further into its pathogenesis. We were interested in knowing whether or not shock produced in this manner could be treated successfully. Since in the control experiments the survival period was much shorter than in the clinical cases of crush syndrome, the studies on therapy presented the added objective of trying to determine whether the typical syndrome would develop if life were prolonged by some form of treatment.

The first attempts at therapy were made by applying a pneumatic rubber tube to the injured extremity immediately after removal of the mechanical press. The tube was fitted with a valve which was connected to a compressed air supply. It was inflated constantly at a pressure of 40 millimeters of mercury. The pneumatic tube was left in place for 13 hours in some experiments and 18 hours in others, a total of 21 experiments being performed. When applied for 13 hours, 3 of the 6 animals died following crush injury, whereas when applied for 18 hours, only 3 of 15 died. The average survival time of the 6 animals which succumbed was 26 hours 9 minutes. The alterations in the various determinations of most of the experiments were less pronounced than those of the previous untreated group. Some of the observations are listed in Table I. It seems likely that the pneumatic tube exerts its beneficial effect by diminishing the loss of fluid into the injured area.

The therapeutic effect of the local application of cold to the injured extremity has been studied (10). In the first 7 experiments, the ice was applied simultaneously with the press and was left in place for the same length of time, namely, 5 hours. Five of the animals survived and the changes were minimal. There was very little swelling of the extremity and the alterations in the blood pressure, hematocrit readings, and urinary findings were much less marked than those in the control experiments. One of the remaining 2 animals died 5 days later of pneumonia. The cause of death of the other animal was not ascertained.

In 6 experiments ice was applied to the injured extremity shortly after the press was removed. No beneficial effect was observed.

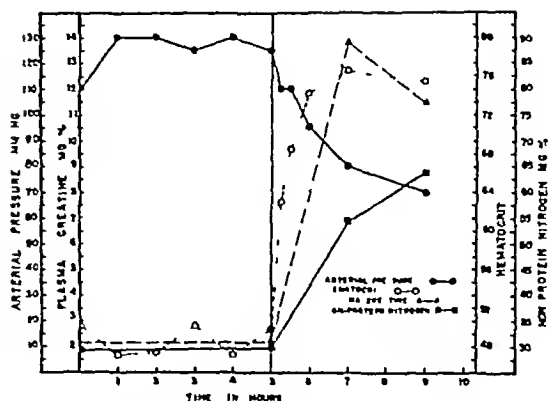


Fig. 1. The effects of removal of the press on the arterial blood pressure, the hematocrit reading, the plasma creatine and non protein nitrogen.

It seems likely that the favorable effect in the studies in which the ice was applied earlier was due to a lowering of the metabolism of the part during the period of anoxia. The results of these experiments are given in Table I.

The third form of therapy that was used consisted of the intravenous administration of blood plasma. The quantity of plasma which was given equalled 33 per cent of the body weight of the animal. This was the average loss of plasma into the injured extremity of the untreated group. The injection of plasma was begun immediately after removal of the press and it was administered slowly over a 1 to 2 hour period. A total of 15 experiments of this type was performed. Nine animals died during the first 40 hours following the removal of the press in an average of 20 hours, the 6 remaining animals survived for 23 days or longer. The alterations in the various functions that were studied were not as great as in the untreated animals. All the animals which died within 40 hours showed numerous granular and red cell casts in the urine and considerable hematuria, whereas the 6 which lived showed only an occasional granular and red cell cast. Examination of the injured extremity of the animals treated with plasma which died within 40 hours revealed swelling which was more pronounced than that found in the untreated group. Bisection and comparison of the weights of the injured and noninjured parts showed a local loss equal to 53 per cent of the body weight as compared to 33 in the

untreated group. Thus, an additional loss equal to 2 per cent of the body weight took place into the injured area, which left unaccounted for a little more than one third of the plasma which was injected. This observation suggests that an additional factor or factors contribute to the fatal results in these animals.

The 6 surviving animals were observed for approximately 30 days. None of the animals showed casts or hematuria after the first few days. Plasma and urinary creatine and creatinine reached normal by the second day and remained within the limits of the control values. We were however again unsuccessful in our efforts to produce the delayed renal alterations which have been described in clinical cases.

In a further effort to understand the effects of crush injuries, it seemed desirable to perform experiments in which the duration of the crushing injury was longer (15 instead of 5 hours) and to determine whether or not death could be prevented by the administration of plasma in doses which were comparable in size to the estimated loss of plasma into and near the crushed area. Four experiments of this type have been performed and death within 30 hours following removal of the press has occurred in all instances, despite the fact that the quantity of plasma introduced was at least equal to the total loss of fluid into the injured extremity. This suggests very strongly that toxic products are formed as a result of the gross injury and the prolonged period of ischemia and anoxemia, and that these exert ill effects when absorbed into the general circulation. The fact remains that the local loss of fluid is great and that it alone would probably have caused shock had not replacement therapy been employed. The beneficial effect which results when the injured part is reperfused during the compression period suggests that the ischemia and resulting anoxia are more important in the sum total of the effects of the crush injury than is the actual gross injury to the tissues.

The type of injury which is produced by this apparatus is one in which a large mass of skeletal muscle is crushed and most, if not all, of the circulation to the extremity is occluded for the time while the press is in place. The

pulse cannot be felt distal to the press but it can be felt immediately after its removal. Thus, local mechanical injury, ischemia, and anoxia play a part in the injury of the extremity and in the large regional loss of plasma. The marked hemoconcentration is further evidence of the loss of plasma. The animals treated by the pneumatic tube were probably saved by the lessening of the fluid loss as a result of the local pressure.

As previously stated we have been unable to reproduce completely the crush syndrome with delayed death which has been observed in patients. As a result of the clinical and experimental observations, several of the possible causes of the crush syndrome will be mentioned as follows: (1) One of us (G.W.D.) has noted tremendous elevations in inorganic phosphorus in animals with crush injuries. It has been previously found that a diet high in phosphate results in tubular lesions in the kidneys of rats. It is possible that this alteration is important in the crush syndrome in patients. (2) Anuria, tubular lesions, and casts have been found to follow mismatched transfusions, the lesions being very similar to those found in the crush syndrome. Most of the patients with the crush syndrome have received transfusions, but this was not the case in at least one instance in which the typical renal lesions were found. (3) Adenine acid has been said to be responsible for at least part of the tubular damage in mismatched transfusions and this substance and other products of muscle metabolism may exist in the injured anoxic muscle. (4) One of the chief features in all the reported cases of crush syndrome has been the presence at some time of shock; the recorded criteria of which are low blood pressure and hemoconcentration. Peripheral circulatory failure may play a part in the precipitation of crystalline and particulate matter. It has been shown that the precipitation in the tubules of particulate matter such as sulfapyridine crystals, is increased in the presence of a low blood pressure and (5) there are a host of possible other toxic products in the injured ischemic tissues.

Upon the basis of the evidence at hand, it seems most likely that prolonged ischemia of an extremity with subsequent flooding of the

general circulation with metabolic products from the ischemic extremity when the constricting object is removed, is of greater importance in the etiology of clinical crush syndrome than direct mechanical injury alone. Further studies are needed in order to determine the possible rôle of infection in the causation of the syndrome.

#### TRAUMA TO SOFT PARTS

Gross trauma to the soft parts of an extremity is a good method of producing shock because it reduplicates a type of injury that is often encountered in patients and because the opposite nontraumatized extremity can be used as a control. Severe trauma to an extremity is followed by the loss of blood into the tissues of the part and by little alteration in the concentration of corpuscles in the blood vessels, slight hemodilution being the usual observation. Milder trauma is followed by the escape of plasma with relatively few red blood corpuscles into and near the injured part, and by hemoconcentration. There is some difference of opinion as to the cause of shock which may follow severe trauma to an extremity, but the prevailing opinion at the present time is that the main initiating factor is the local loss of fluid into and near the injured area (5, 18). There seems to be little doubt that this is the case in shock which develops within the first few hours following the injury. It must be said, however, that the absorption of toxic products and the effects of nervous stimuli have not been excluded as important agencies in the causation of shock following this type of trauma. This is particularly true in those instances in which shock develops a number of hours after the injury.

Proof that shock can be produced experimentally when the local loss of fluid is restricted was presented by Freedman and Kabat in studies in which they traumatized extremities that had been bound with tape. The agencies other than the local loss of fluid which are responsible for shock produced in this manner require further investigation. It is of interest that Freedman and Kabat found that preliminary transection of the upper lumbar spinal cord prevented the development of shock as caused by their method.

From the experimental viewpoint, it may be stated that shock which can be explained on the basis of local fluid loss alone can be produced by gross trauma to extremities. On the other hand, it seems quite likely that other factors play a part in many instances of gross trauma. The rôle of the nervous system is difficult to evaluate because anesthesia is required. It seems unlikely that nerve stimuli ever serve as the sole initiating agent, but it is probable that they play a part in the cause of shock.

Probably the best clinical study of shock is that which was recently reported by Whitby and his associates (16). It is commented upon in this place because most of the patients had injuries to soft parts. They made a systematic study of 24 patients who had been severely injured. A typical example is the following case report.

"CASE 3. Male, aged 24. Seen  $3\frac{1}{4}$  hours after injury. Multiple small injuries of back, legs and arms, gaping hole in right buttock 9 in in diameter, buttock almost completely removed, perforating wound left wrist joint. Morphia gr  $\frac{1}{4}$   $1\frac{1}{4}$  hours after injury. Warmed with electric blanket for  $1\frac{1}{4}$  hours before transfusion. Mentally clear, pain 2 plus, thirst 1 plus, pallor 2 plus, cyanosis 2 plus, sweating slight, T  $95^{\circ}$  F, P 82, B P 40/30, Hb, ear 120%, vein 100%, hematocrit 43%.

"After 1 pint plasma in 20 min P 100, B P 70/40. After 2nd pint plasma in 20 min P 120, B P 80/45. After 3rd pint plasma in 20 min P 128, B P 100/55, Hb, ear 80%. Greatly improved but pallor still extreme, 1 pint blood given in 30 min P 120, B P 100/60. Started bleeding from buttock, 1 pint blood given in 30 min. During operation of débridement, at which much bleeding, 2 further pints blood administered, each in 15 min. Anesthetic G O E. After operation P 110, B P 112/70. After 24 hours general condition good, P 120, B P 115/80, Hb 78%."

A number of statements by Whitby and his associates are of sufficient importance to merit repetition. They state "In all cases seen by us it has appeared that the loss of blood-volume can be accounted for by external loss and by extravasation into the injured area. In no case has there been any evidence to suggest loss of plasma in regions remote from a seat of injury." Even though we have stressed for a number of years the importance of the local loss of fluid in the cause of shock, it would be surprising if in Whitby's patients there were

not other factors which played a part in the cause of traumatic shock.

In connection with the search for a universal early criterion of shock, the statements by Whitby and his associates are discouraging. They found that the pulse rate is an unreliable indicator and that in the absence of blood pressure readings attention should be paid to the volume of the pulse rather than to the rate. It was noted that the cardinal symptoms of shock may be present without much hemoconcentration or hemodilution. They state "In observing 25 cases of secondary shock a sustained and serious fall in blood pressure, in spite of simple resuscitation procedures, has been found to be the one reliable clinically measurable criterion of the severity of the condition." In most instances of secondary shock vasoconstriction is present, and thus the arterial blood pressure may remain elevated even after a rather pronounced decrease in the blood volume and cardiac output. Hence, the decline in blood pressure is usually not an early alteration in shock and it is to be hoped that an earlier index will be found. For the present, we are inclined to agree with Grant and Reeve in their statement that in assessing the need for treatment emphasis should be placed on the severity of the injury and on blood loss, rather than on the blood pressure.

Blood pressure determinations are of particular value in evaluating the response to treatment. Whitby and his associates state that, as a rule, a rise of 10 to 20 millimeters of mercury can be anticipated for every 540 cubic centimeters transfused, if bleeding has ceased and no other causes of loss of circulating plasma are operating. A quantitative replacement of lost fluid should be attempted. It is fortunate that the old custom of not giving more than one pint of blood to a patient has been discarded. If the injury is severe usually several pints are required.

A series of experiments has been performed recently which adds to the information regarding the mechanism of shock following injury to soft parts, and, in addition, the results demonstrate clearly the harmful effects which may follow the prolonged use of a tourniquet. An extremity was traumatized as in previous

experiments by striking the thigh of the anesthetized animal a number of blows with a hammer. An attempt was made to produce the same amount of injury that had been caused in the previous studies. Shortly following the traumatization blood plasma was given intravenously in an amount which equalled 5 per cent of the body weight of the animal. All of these animals recovered. In a second series of experiments, the trauma was carried out in an identical manner and immediately a tourniquet consisting of heavy rubber tubing was placed tightly around the thigh just proximal to the site of trauma. The tourniquet, which was placed on tightly enough to cut off the arterial inflow as well as the venous return of the soft parts, was left in place for 5 hours. It is to be remembered that a similar period of ischemia was caused in most of the experiments on crush injuries. There was no evidence that the condition of the animals changed materially during this 5 hour period. As soon as the tourniquet was removed the intravenous administration of plasma was begun and the amounts given in the various experiments varied from 5 to 15 per cent of the body weight of the recipient. Even the use of the larger quantities did not prevent the death of the animals. In some of the experiments the loss of plasma into the injured part was not so great as the quantity which had been injected.

These studies indicate very clearly the vastly different effects are produced by (1) trauma alone and (2) the same amount of trauma plus the prolonged application of a tourniquet. When gross trauma alone is caused most of the alterations can be explained on the basis of local loss of fluid. When ischemia and anoxia are superimposed by the prolonged application of a tourniquet, the local loss of fluid following the removal of the tourniquet is great but death is not prevented by introducing fluid which is sufficient to replace the local loss. In other words, a general type of alteration in the circulation system is produced. Burns result in the death of some tissues and probably in a diminution in the blood supply of some parts which ultimately survive. It is quite possible that the effects of burns are intermediate between

gross trauma alone, on the one hand, and trauma on which ischemia is superimposed, on the other

From a practical standpoint, these studies emphasize what is known but is not generally appreciated regarding the harmful effects of the use of tourniquets on the injured extremities of patients. Wilson and Roome (22) found that the removal of a tourniquet is followed by the passage of a considerable portion of the blood volume into the dilated vessels of the extremity, and at times by a decline in blood pressure. A tourniquet should be used for the control of bleeding only if other measures are not available or are not adequate. It was noted by Allen that constriction of the circulation of the thigh is more likely to be followed by the development of shock if the temperature is high than if it is low. Brooks and Duncan found that the temperature of the part is of great importance in determining the survival period of ischemic tissue. Our experiments on crush injuries show that many of the ill effects can be avoided by refrigerating the part during the time in which anemia and ischemia are present. If it is necessary to use a tourniquet on an injured extremity, these observations indicate that the part distal to the tourniquet should be cooled if facilities for accomplishing this are available.

#### SUMMARY

Four types of injuries that are frequently encountered in warfare are considered. These are blast injuries, burns, crush injuries, and gross trauma to the soft tissues of extremities. The type and the extent of regional fluid loss in these conditions are discussed.

The observations on crush injuries and gross trauma to soft parts indicate that there is a distinct difference in the effects of trauma alone and of trauma to which an interference with the blood supply to the part is superimposed. The effects of gross trauma alone appear to be mainly local, whereas the addition

of ischemia and anemia to trauma results, upon release of the constriction, in general alterations in the circulatory system as well as in local changes.

The results emphasize the desirability of controlling hemorrhage by means other than the application of a tourniquet. If it is necessary to apply a tourniquet, it should be left in place for as short a time as possible unless the part is to be amputated. Cooling of the part distal to a tourniquet greatly reduces the chances of the development of shock following the release of the constriction.

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## PLASMA THERAPY IN SEVERE BURNS

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THE general treatment of burns is of prime importance and must be carefully correlated with the local therapy. The management of the patient attempts to bring him past four serious stages in the chronological course of a burn, namely: (1) primary shock, (2) shock, (3) toxemia, (4) infection.

As shown in Figure 1, these four stages overlap, but in general they have rather definite times of appearance. The general treatment of burns should be directed against deaths occurring during these four stages. The steady progression of abnormal developments requires, however, that such treatment should be rapidly instituted continuously carried out, and meticulously followed through as long as is necessary.

For all practical purposes the treatment of primary and secondary shock need not be separated. Nine times out of ten by the time the patient has reached the hospital even though all the signs of primary shock have not disappeared, evidences of secondary shock will already be present in instances in which that condition is going to develop. Harkins (1934, 1935) reported the results of tipping experiments on dogs subjected to unilateral trauma. These demonstrate that 50 per cent of the total plasma shift in such animals will have already occurred at the end of the first hour. Clinical observations of the hematocrit indicate that when hemoconcentration occurs such an increase is liable to be in evidence early. Penberthy (1941) reported that the most marked rise in the hematocrit occurs during the first 6 hours. Penberthy had one patient with very severe burns and a hematocrit of 70 per cent at the end of 1 hour after the burn, indicating a loss of approximately one half of the normal plasma volume. Tenery (1940) stated in this regard that in clinical

cases the hematocrit rises rapidly so that approximately one half of the hemoconcentration that is likely to occur is present at the end of 6 hours. These observations indicate the early onset of signs of secondary shock and the fallacy of trying to separate its treatment from that of primary shock.

In the early stages of a severe burn it is desirable that the course of the patient be followed by adequate laboratory and clinical tests. Such observations aid in deciding upon the choice and dosage of therapeutic agents. The following routine is suggested as ideal, but except in large institutions or in military hospitals during periods of relative inaction, such a schedule would have to be trimmed considerably. Of all the determinations listed here, observation of the hematocrit (or hemoglobin or red blood count) is the most important. No other single test gives as much information concerning the status of a burn patient from a therapeutic standpoint. Hemoconcentration, not arterial blood pressure fall, is the first sign as a rule of impending burn shock and therefore of the necessity for fluid replacement. In shock of no other origin does uncomplicated hemoconcentration occur so often as after burns. The wise surgeon should take advantage of this singular opportunity.

Suggested determinations include:

- Chart blood pressure every 2 hours the first 48 hours and every 8 hours the next 5 days unless below 90 systolic when more frequent readings are necessary.
- Chart temperature, pulse and respiration every 2 hours.
- Chart daily fluid intake and output, with specific gravity of each urine specimen the first 3 days and later if the daily output is below 1500 cubic centimeters.
- Determine the hematocrit (or hemoglobin or red blood count) every 3 hours during the first 12 hours and thereafter if elevated, and daily for the first week. Subsequently if secondary anemia develops, as it

TABLE I — BERKOW'S METHOD FOR ESTIMATING THE EXTENT OF A BURNED AREA

Region	Per cent body surface involved
Head	6
Upper extremities	
Both arms and forearms	13½
Both hands	4½
Total	18
Trunk	
Anterior surface	20
Posterior surface	18
Total	38
Lower extremities	
Both thighs	19
Both legs	13½
Both feet	6½
Total	38

does so frequently after third degree burns, these same determinations are of great value in the control of this late complication

e Optional observations include a daily *white blood count*, *urinalysis*, and blood chemical examination. For the latter, *plasma proteins*, *icteric index*, *carbon dioxide combining power*, *chlorides*, and *plasma potassium* are useful in more or less decreasing importance

#### TREATMENT OF TOXEMIA AND SEPSIS

The management of burn shock should be carried out along with preventive measures against toxemia and sepsis

*Toxemia* This complication is especially apt to occur during the second to the fourth day after a burn. The presence of jaundice, increase in the icteric index, decrease in the urinary output, stupor, and a demonstrable decrease in liver function are all prodromal signs. The liver function tests show a decrease in prothrombin percentage (Table II Case 1) and hippuric acid excretion and an increase in bromsulfalein retention and a positive cephalin cholesterol test. Adequate glucose (more than 150 gms daily) and sufficient sodium chloride to maintain equilibrium (usually 1000 cc of normal salt solution daily, although when vomiting occurs more should be given in accordance with well known surgical principles) are advised. Use of these crystalloid solutions in reasonable amounts as well as of adrenal cortical extract to prevent burn toxemia conforms with the control of burn shock

*Sepsis* The treatment of sepsis is largely

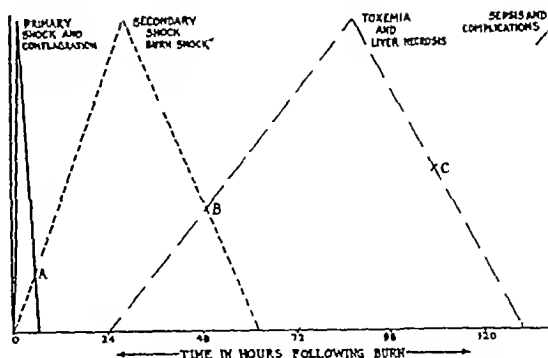


Fig 1 Chronological course of a burn showing the four serious stages. From O to A, primary shock is predominant, from A to B, secondary shock, from B to C, toxemia, after C, sepsis and complications (Modified from Gunn and Hillsman)

preventive by the use of careful local therapy and therapeutic by the adoption of adequate sulfonamide control. In either instance, the early treatment of shock is not impeded

#### RELATION TO LOCAL TREATMENT

Tannic acid and other tanning agents have done more to reduce the mortality during the first 48 hours than during the later course of burns. Whether the tanning method does this by sealing off the damaged tissues and preventing fluid loss or by precipitating and diminishing the absorption of toxic products is still uncertain. But the fact remains that during this period the mortality has been markedly diminished. Even granting, then, that certain local remedies may give a better cosmetic result on the face or hands, it would seem that in severe burns local treatment should be chosen with an eye toward the prevention of shock and saving of the life of the patient rather than only to the ultimate cosmetic result. In the absence of adequate plasma for transfusion, tanning should promptly be applied in severe burns, in such cases oils and saline dressings or baths should be reserved for mild extensive or localized deeper burns. The vaseline gauze-pressure dressing method of local burn treatment also helps minimize the local loss of plasma

#### TREATMENT OF BURN SHOCK

The treatment, essentially consisting of 4 types, is both prophylactic and therapeutic



TABLE II.—MISCELLANEOUS CHEMICAL STUDIES OF CASE T W

Date	7-21 (Sun)	7-22	8-1	8-4	8-5	8-7	8-8
Blood chemical analysis							
K.P. X (mgm. per 100 c.c.)	31			21		66	
Chlorides (mgm. per 100 c.c.)	37			233	407		
Sodium (mgm. per 100 c.c.)	19.3			31			
Potassium (mgm. per 100 c.c.)	16			17.3			
Sugar (mgm. per 100 c.c.)						200	100
Bullousinamide (mgm. per 100 c.c.)					4.5		
CO <sub>2</sub> (vol. %)						61.1	
Prothrombin (%)				30		29	
White blood count		4,400			17,000	20,000	11,300
Leuc. function test							
Oral hypoglycemic test (gram)			2.45			1.40	

1 *Supportive treatment* Rest and quiet are advisable. Elevation of the lower extremities is useful as a temporary emergency remedy but does not get at the source of the trouble. Warmth may be harmful in excess as shown by Hilgenfeldt (1939) and by Blalock and Mason (1941). For this reason it is best not to have burn tents warmer than 85 degrees F. Sedatives are useful for relieving early pain, but later may exaggerate a tendency toward anoxia. Stimulants are of value only when respiratory depression is present. Vasospasms are essentially a symptomatic remedy and give only a temporary benefit.

2 *Oxygen* This is of value in all serious cases. Nasal catheters may be used in mild cases and oxygen tents in more serious instances when a higher concentration of oxygen is desired. In extreme cases the B.L.B. mask with its capability of giving 90 per cent oxygen or more should be applied.

3 *Adrenal cortical extract* This mode of therapy is still in an experimental stage but offers much promise as a specific remedy. Differentiation should be made between relatively pure glandular extracts, impure glandular extracts and synthetic desoxycorticosterone acetate which may not all have the same therapeutic effect. Rhoads, Wolff and Lee (1941) reported that without adrenal cortical extract about 40 hours are required for the capillary walls to recover their normal state of permeability for proteins. When

adrenal cortical extract was given, such a *restitutio ad integrum* occurred as early as the eighteenth hour.

4 *Fluid replacement therapy* This is the cornerstone of all burn shock treatment. Crystalloid solutions (saline and glucose) have only a temporary benefit, but in small amounts are necessary adjuncts to other more specific therapy. Whole blood is not harmful, but in the early stages of treatment, its contained erythrocytes are superfluous. However, like a diet with much bulk it is far better than nothing.

Blood plasma is the best treatment known at the present time for the treatment of burn shock. Since it is essentially plasma which is lost in burns rather than whole blood, the use of plasma would seem logical. Its adoption was suggested by Low (1937), Montgomery (1937) and Seeger (1938). Weiner, Roskitt, and Elman (1936) in a study of 40 severely burned patients first reported the clinical use of plasma in such cases. In their report it was shown that intravenous glucose and saline accomplished little, the plasma protein level continuing to decrease and the hematocrit continuing to increase. Intravenous gum acacia or plasma, however, was definitely of benefit. During the past 3 years the use of plasma has been the chief development in the general management of burns. Plasma has been used by Elkinton in 1939 by Atkins, Black, Cohen, Darrow, Elkinton *et al.*, Minor and Blalock, Noland and Wilson, Scudder

Tenery, Vaughan, Wakeley, and White, Collins, and Weinstein in 1940, by Allen, Elman, Harkins, Lam, Penberthy, and Robson and Wallace in 1941, and by Harkins (1942)

#### DOSAGE OF PLASMA

The administration of adequate amounts of plasma is essential. There is no more reason for always giving a burned patient a pint of plasma than for always giving a diabetic patient 10 units of insulin. Large amounts of plasma have been given by some writers. Strumia, Wagner, and Monaghan (1940) gave 7,300 cubic centimeters of plasma to one burned patient in 11 days. Minot and Blalock (1940) gave a patient with severe burns 5,000 cubic centimeters of blood plasma as well as other amounts of whole blood and other fluids during the first 19 days of illness. Large amounts of plasma were also given by Rhoads, Wolff, and Lee (1941) and by others.

With the necessity for administration of large amounts of plasma, the advisability of methods for calculation of the plasma dosage is evident. Such dosage is best controlled by careful and repeated estimation of the blood concentration (hematocrit, hemoglobin, or red blood cell count). With blood banks available it is relatively easy in civilian practice or in military hospitals during periods of relative inaction to obtain large amounts of plasma. The adoption of preserved or dried plasma extends its usefulness to the front line and active engagements.

There are 4 methods available for calculating the plasma dosage, as follows:

*a First aid method of Harkins (1941)* In many cases in which burns are treated in places remote from hospitals or near the front line in war, plasma may be available yet methods for determining hemoconcentration may not. In such instances the extent of the burn and consequent plasma dosage can be roughly calculated by Berkow's method (Table I). For deep burns (arbitrarily, those deep enough to cause blistering), the rule can be adopted of giving 50 cubic centimeters of plasma for every per cent of the body surface affected by such a burn. This could also be expressed as a pint of plasma for each 10 per cent of the body surface so involved.

*b Method of Black (1940)* As used in Great Britain, this involves the following formula

X=amount of plasma to be given in c c

$$X = (5 - \frac{500}{Hb_2}) \times 1,000, \text{ where } Hb_2 \text{ is the hemoglobin observed after the burn}$$

*c Method of Elkinton, Wolff, and Lee (1940)* This involves the use of an even more complicated formula and takes into account both the extent of hemoconcentration and possible low plasma proteins

Y=amount of plasma to be given in gm

$$Y = 3.5 W - \frac{W(100 - H_o) H_n P_o}{2(100 - H_n) H_o}, \text{ where}$$

W=body weight in kgm

H<sub>o</sub>=observed hematocrit

H<sub>n</sub>=normal hematocrit (=44)

P<sub>o</sub>=observed plasma protein in gm/100 c c

This formula can be simplified from this unwieldy form substituting the assumed value of 44 for the patient's normal hematocrit, and by expressing the result in cubic centimeters of plasma to be given instead of in grams (since donor's plasma is never analyzed quantitatively anyway)

X=amount of plasma to be given in c c

$$X = 49 W - \frac{5.5(100 - H_o) P_o W}{H_o}$$

*d Method of Harkins (1941)* This is the simplest of the methods depending on extent of hemoconcentration. It is to give 100 cubic centimeters of plasma for every point the hematocrit exceeds the normal of 45. This formula can be adapted to hemoglobin estimations, in which the dosage should be 50 cubic centimeters of plasma for every point the hemoglobin exceeds the normal of 100 per cent. The method involves the same assumption as the other methods, namely that the patient's pre-burn blood concentration was normal. The amount of plasma is calculated for adults, while for children it can be reckoned proportionately according to the body weight, the average adult weight being assumed to be 70 kilograms. When the plasma protein is below normal, the simplified method gives too low a value. If such a hypoproteinemia is present, an additional 25 per cent of the calculated

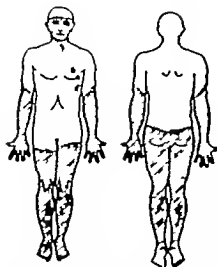


Fig. 2. Diagram of burned areas of patient T. W. Case. Borkow formula shows head, 3 per cent; hands, 4.5 per cent; arms, 8 per cent; feet, 5 per cent; legs, 4 per cent; thighs, 7 per cent; total burned area of 48 per cent of body surface.

amount of plasma should be added for every gram the protein level is below 6.0 gm./100 cubic centimeters. In adequately treated cases experience has shown however that low plasma proteins are seldom observed in the first few weeks after a burn. Only when no blood or plasma has been given and when the blood has been diluted by large amounts of intravenous crystalloid solutions are low plasma proteins apt to be observed. Thus, the correction to Harkins formula for such an eventuality seldom need be considered in actual clinical practice.

Four illustrative cases will now be analyzed and the results by the four methods compared.

**CASE 1.** T. W. No. 33539, male aged 3 years, received second and third degree burns of approximately 48 per cent of the body as shown in Figure 2. Patient's clothing was ignited by hot molten metal at 3 p.m. on July 3, 1941. He was treated at hospital 1 hour later by debridement followed by tannic acid bath and the application of resorcinol and silver nitrate. Shock developed temporarily despite the early use of plasma. He received 4700 cubic centimeters of plasma during the first 38 hours. July 20, 1941, 5 cubic centimeters of adrenal cortex was given twice intravenously with plasma, then every hour intramuscularly for 70 hours finally cubic centimeters every 4 hours intramuscularly until stopped August 6, 1941. Thirty grams of sul-

famylamide was given orally August 4, 1941, then every 4 hours for 3 days. One tablet kayser soon was given three times a day starting August 5, 1941. Synkamin, 1 ampul, was given twice a day August 6, 1941, then ampule twice a day August 6, 1941. August 7, 1941, old insulin was started and he received a total of 145 units in divided doses before he expired at 7:30 p.m. August 8, 1941, with blood sugar 528 despite no recent glucose injections. Daily specimens of urine showed albumin, 10+ casts, only first days, sugar 1+ to 4+ ketone bodies absent no red blood cells few white blood cells. Bile was present on the 3 days before death. The results of various blood chemical analyses are shown in Table II. A complete outline of the calculations of the plasma dosage at various times is given in Table III. As seen from this table, the admission hematocrit 4 hours after the burn at 3 p.m. was 61. It had risen to 73 4½ hours later despite the administration of 600 cubic centimeters of plasma.

Peak hematocrit as 73 per cent plasma protein, 7.33 grams per 100 cubic centimeters body weight approximately 70 kilograms 50 cubic centimeters plasma given in 1 hour.

#### Calculation of Plasma dosage

*a First aid formula.* Since 48 per cent of the body surface is involved by a deep (blistering) burn the total plasma dosage should be 2400 cubic centimeters (50 c.c. for each per cent).

*b Formula of Black.* (Thus and the following 3 illustrative calculations will be made for the 9:30 p.m. hematocrit reading only.)

Hematocrit of 73 corresponds to hemoglobin of 160

$$X = (5 \frac{500}{60}) 1000 = 830$$

1880 c.c. plasma needed.

*c Formula of Elkinton and associates*

$$X = 49 \times 70 - \frac{5 \times 7 \times 70 \times 73}{72}$$

$$X = 90$$

90 c. plasma needed.

*d Formula of Harkins*

Hematocrit of 73 is 28 points above normal or 45 and plasma protein is above 6 gm/100 c.c.  
300 c. plasma needed.

A comparison of the results of the four formulas indicates a reasonably good agreement. As seen in Table III this agreement for the three main formulas holds good for the entire period of observation during the first week following the burn. In fact there is less

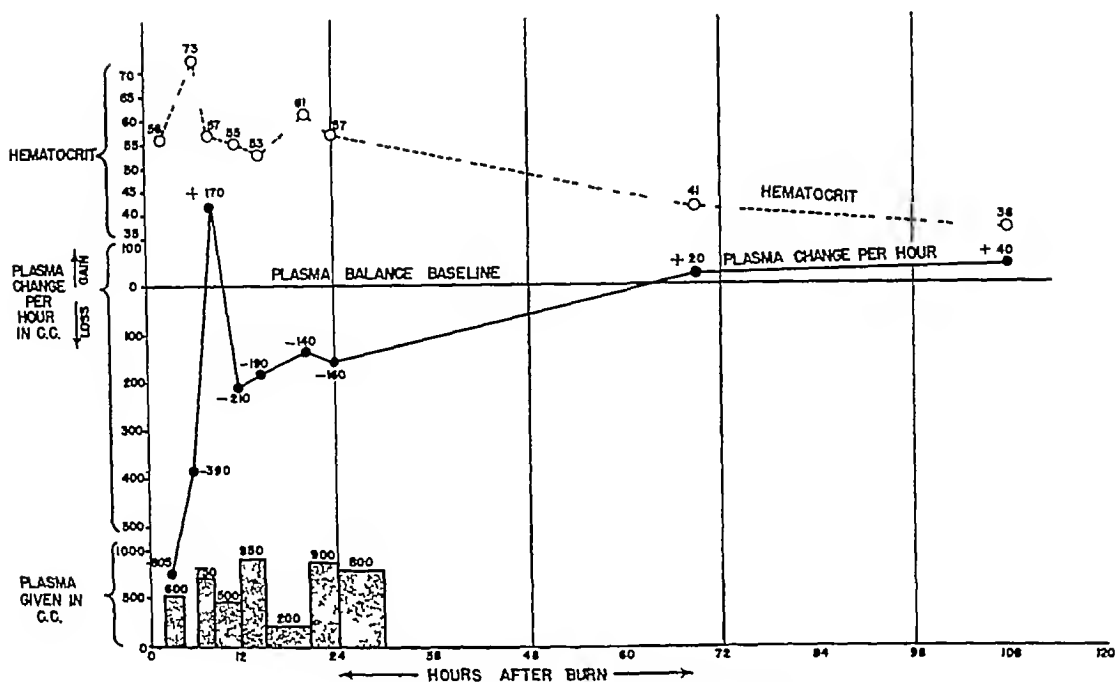


Fig 3 Plasma balance studies of patient T W Case 1

disparity in most of the results than in the illustrative example used above. During the recovery period the calculations by the simplified formula do not take into account excesses of plasma. From the practical standpoint this is not important.

Another way of charting the plasma balance is shown in Figure 3. This type of chart is new and represents a modification of that used by

Rhoads and associates (1942). The hematocrit readings are graphed at the top and the amount of plasma is given at the bottom. The middle line represents the plasma change per hour in cubic centimeters. This is listed as a loss (negative values) or a gain (positive values) in the calculated amount of plasma in the blood stream. In this particular chart, the values are calculated by the formula of Elkin-

TABLE III—CALCULATION OF PLASMA DOSAGE DURING FIRST WEEK AFTER BURN IN CASE OF T W

Time	7 28 41			7 29 41				7 31 41	8-2 41	8-5 41
	5 p.m.	9-30 p.m.	11 30 p.m.	1 a.m.	5 a.m.	11 30 a.m.	3 p.m.			
Hematocrit	56	73	57	55	53	61	57	41	36	35
Hemoglobin (calculated from hematocrit)	124	162	126	122	118	134	126	91	80	78
Plasma protein (gm/100 c.c.)	7.33	*	*	*	*	*	*	6.10	6.32	7.47
1. Calculated plasma dosage, c.c. (Method of Elkin et al.)	1210	2390	1300	1120	930	1640	1300	50	-880	-1910
2. Calculated plasma dosage, c.c. (Method of Black)	970	1910	1030	870	770	1270	1030	-490	-1260	-1420
3. Calculated plasma dosage, c.c. (Method of Harkins)	1100	2800	1200	1000	800	1600	1200	0	0	0
Actual amount of plasma given c.c. (after readings)	600	750	500	950	200	900	800	0	0	0

\*Plasma protein assumed to be 7.33

TABLE IV—CALCULATION OF PLASMA DOSAGE DURING FIRST WEEK AFTER BURN IN CASE OF B.S.

Date	4-1 (a.m.)	4-2 (p.m.)	4-3-4-4	4-5-4-6	4-7-4-8	4-9	4-10
Hematocrit	77	81	76	7	40	40	37
Hemoglobin (calculated from hematocrit)	26	27	25.5	23.5	30.5	30	28
Plasma proteins (gm./100 c.c.)	7	7	8	7	6	5	
Calculated plasma dosage method of Eklinton, et al.	30	1750	970	1,000	970	30	240 (from)
Calculated plasma dosage method of Black	1000	1,150	970	650	30	450 (margin)	470
Calculated plasma dosage method of Harrison	300	1700	300	700	400		
Actual amount of plasma given (after reactions)	300	1,000	700				

ton and associates, although the method of Black or that of one of us (H.N.H.) would have given comparable values. The first point on this line represents an average plasma loss from the blood stream per hour of 605 cubic centimeters at a time 3 hours after the burn (5 p.m.) This is calculated from the results shown in Table III. The Eklinton formula indicates a 1210 cubic centimeter deficit after 3 hours or 605 cubic centimeters per hour. The second point showing an average loss of 300 cubic centimeters per hour is calculated similarly. At 9:30 p.m. the Eklinton formula indicates a 2390 cubic centimeter deficit. This is 1180 cubic centimeters more than at the last reading and exists despite the administration of 600 cubic centimeters plasma. The new loss occurring from 5 p.m. to 9:30 p.m. is thus 1180 plus 600 or 1780, divided by the time interval

of 4½ hours. This equals 390 cubic centimeters per hour. Other points are calculated accordingly. We have no explanation for the one aberrant point (the third) on the plasma change line. It undoubtedly illustrates the inaccuracies of the methods, and may mean that the previous peak hematocrit of 73 which was taken from very sluggish capillary blood (from an abdominal skin puncture wound) represents too high a value. Despite this, the steady decrease in plasma loss with a complete recovery of plasma balance on the third day is of extreme interest. The time of this recovery roughly corresponds with that reported by Rhoads, Wolff and Lee (1941). Since this particular patient received adrenal cortical extract the slowness of recovery does not in itself argue for the use of this drug. More likely however the late return to nor-

TABLE V—CALCULATION OF PLASMA DOSAGE DURING FIRST FIVE DAYS AFTER BURN IN CASE OF W.K.

Time	4-42			4-43		4-46		4-47
	m.	ss.	300 m.	4.20	4.30	4.40	4.50	
Hematocrit	40	43	57		1	40	47	
Hemoglobin (calculated from hematocrit)	100	107	120	15	15	100	107	120
Plasma proteins (gm./100 c.c.)	7.0	7.2			6	4.7	5	5
Calculated plasma dosage, Method of Eklinton et al.	430	830	1530	130	300	1000	730	930
Calculated plasma dosage, Method of Black	300	230	1000	600	600	430	150	450
Calculated plasma dosage, M.C. Method of Harrison	300	300	300	300	300	300	300	
Actual amount of Plasma given (after reactions)			300		600			

\*Plasma proteins assumed to be 7.5  
 †Plasma proteins assumed to be 4.7

mal represents the combined effects of extreme damage to the capillaries and administration of very large amounts of plasma. In no other patient did we encounter such high values for the plasma loss per hour. For example, in Case 2, the highest loss observed was 210 cubic centimeters per hour. It is to be noted, however, that this last figure represents an average over a six hour period, while the high figure for the first case is over only the first two hour period when the leakage is most rapid.

**CASE 2** B S, male, aged 21, with severe burns shown in Figure 4, was admitted with a hematocrit of 57. His course is shown in Table IV. Three hundred cubic centimeters of plasma was given immediately after the initial hematocrit. The patient was burned at 3 a. m. on February 11, 1941, when his oil soaked clothes caught on fire after an oil stove had exploded. Resoreitannol jelly and, later, sulfaguanidine were applied locally. The patient received 2 cubic centimeters of cortate intramuscularly every 4 hours for 5 days and one dose of 1500 units of tetanus antitoxin. He was given 2200 cubic centimeters of blood plasma during the first 36 hours after the burn. He was never in severe shock, but died April 7, 1941, 55 days after the burn.

#### *Calculation of plasma dosage*

*a First aid formula* Since 43 per cent of the body surface is involved by a deep (blistering) burn, the total plasma dosage should be 2150 cubic centimeters (50 c. c. for each per cent).

*b Formula of Black* Hematocrit of 57 corresponds to hemoglobin of 126

$$\lambda = (5 - \frac{500}{126}) 1000 = 1040$$

1040 c. c. plasma needed

#### *c Formula of Elkinton and associates*

$$V = 49 \times 68 - \frac{5.5 \times 43 \times 7.5 \times 68}{57}$$

$$V = 1250$$

1250 c. c. plasma needed

#### *d Formula of Harkins*

Hematocrit of 57 is 12 points above normal of 45 and plasma protein is above 6.0 gm./100 c. c.

1200 c. c. plasma needed

The agreement between the methods b, c, and d is striking, both for this determination and for subsequent ones shown on Table IV.

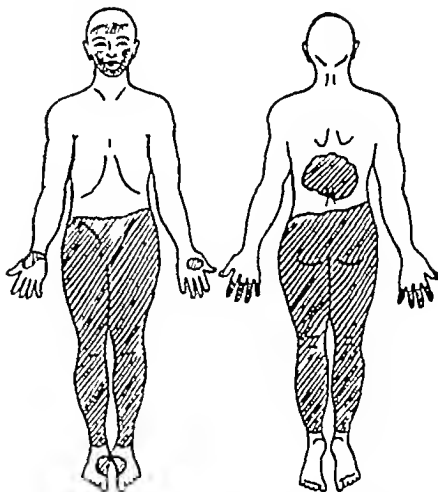


Fig. 4. Diagram of burned areas of patient B. S. Case 2. Berkow formula shows  $\frac{1}{3}$  of head, 2 per cent,  $\frac{1}{36}$  of hands and arms, 0.5 per cent,  $\frac{1}{7}$  of anterior trunk, 3 per cent,  $\frac{1}{4}$  of posterior trunk, 4.5 per cent, both thighs 19 per cent, both legs, 14 per cent, a total of 43 per cent of body surface.

The larger amount of plasma (2150 c. c.) indicated by method a, the first aid formula, would at first glance seem a discrepancy. Actually, however, it is not, as this formula indicates at one reading—as well as can be done, it is believed—the entire amount of plasma that will be necessary. The other methods indicate fractionally that amount which is required at different periods during the course of the burn. It is to be observed that the actual amount of plasma given, 2200 cubic centimeters, corresponds almost exactly to that calculated by the first aid formula.

**CASE 3** W K, No. 339121, white male, aged 37 years, with 20 per cent of the body surface burned, was treated as follows (Table V). Patient was admitted to the hospital August 6, 1941. He had been burned at 10:55 a. m., when a gas burner ignited while he was cleaning a furnace. His hands were further burned as he attempted to remove clothing. He was brought to the hospital within an hour and presented no evidence of shock. Local treatment consisted of cleansing of the wounds with green soap and débridement. Wounds rinsed with saline. Tannic acid spray was followed by 10 per cent silver nitrate except over the hands and face which were treated with cod liver oil ointment and pressure dressings. He received a total of 1150 cubic centimeters of citrated plasma in two transfusions during the first 28 hours. Infection was minimal and healing was rapid. Epithelization was complete by September 13, 1941 with practically no scarring or functional impairment.

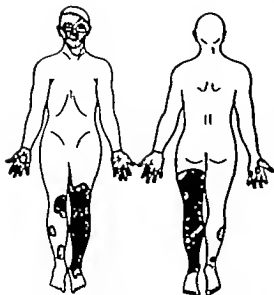


Fig. 5. Diagram of burned areas of patient M. K., Case 4. Berkwitz formula shows  $\frac{1}{4}$  of head, 3 per cent; head and  $\frac{1}{4}$  of other 3.5 per cent,  $\frac{1}{4}$  of thigh, 0.5 per cent, leg, 7 per cent. Total of 3 per cent of body surface.

#### Calculation of plasma dosage

a. *First aid formula* Since 20 per cent of the body surface is involved by a deep (blistering) burn the total plasma dosage should be 2000 cubic centimeters.

b. *Formula of Black* (This and the subsequent two calculations are for the maximum hematocrit of 57 shown in Table V.)

Hematocrit of 57 corresponds to hemoglobin of 26.

$$V = (S \frac{100}{26}) 1000 = 410$$

41 c.c. plasma needed.

#### c. *Formula of Elkinton and associates*

$$V = 49 \times 85 \frac{5.5 \times 41 \times 6.55 \times 85}{57}$$

$$V = 85$$

850 c.c. plasma needed.

#### d. *Formula of Harkins*

Hematocrit of 57 is 5 points above normal of 45 and plasma protein is above 6 gm./100 c.c.

1000 c.c. plasma needed.

In this case the formulas agree fairly well. Again the first aid formula indicates the total

dosage and this is essentially what was given (1000 calculated, 1150 given). Because of the fact that the Elkinton formula takes better cognizance of the weight of the patient, it led to higher values for the plasma needed than did the two other formulas. The differences in this case were not, however therapeutically significant.

CASE 4. M.K., male, aged 38 years, admitted with severe gasoline burns of lower extremities estimated at 3 per cent of the body surface as shown in Figure 5. Initial hematocrit was 60 per cent; initial plasma protein, 6.65 grams per 100 cubic centimeters body weight, 80 kilograms. 2000 cubic centimeters of plasma given in 12 hours.

#### Calculation of plasma dosage

a. *First aid formula* Since 23 per cent of the body surface is involved by a deep (blistering) burn, the total plasma dosage should be 2150 cubic centimeters.

#### b. *Formula of Black*

Hematocrit of 60 corresponds to hemoglobin of 3

$$V = (S \frac{100}{37}) 1000 = 115$$

115 c.c. plasma needed.

#### c. *Formula of Elkinton and associates*

$$V = 49 \times 80 = \frac{5.5 \times 80 \times 4 \times 6.65}{60}$$

$$V = 960$$

960 c.c. plasma needed.

#### d. *Formula of Harkins*

Hematocrit of 60 is 5 points above normal of 45 and plasma protein is above 6 gm./100 c.c.

1500 c.c. plasma needed.

After 2000 cubic centimeters of plasma were given this patient the new hematocrit was 45 (normal) new plasma protein was 6.49 grams per 100 cubic centimeters and no further plasma was needed.

#### EFFICACY OF PLASMA IN CONTROLLING BURN SHOCK

The importance of burn shock, especially in time of war is evident. Various estimates have put the percentage of burn deaths that are due to shock at from 60 to 75 per cent of the total number of deaths. Wilson (1928) reported that 63 per cent of his 80 burn lab-

ties occurring from 1913 to 1925 were from shock, Seeger (1937) reported a shock death percentage of 64 per cent of his total burn deaths, and Klotz (1938) reported 70 per cent. The most recent figures in this regard are those of Atkins (1940) who had considerable experience in treating burn cases evacuated from Dunkerque. This writer stated "Secondary shock is the most serious factor in burns occurring in this condition." Naturally, with adequate therapy the figure will not run this high, but the fact still remains that in about two-thirds of serious burn cases patients will die of burn shock if untreated. It should be pointed out, however, that many patients may be saved during the shock period only to die later of other complications. Such a fate was met by two of our own most serious cases (Cases 1 and 2).

The work of others on the efficacy of plasma in controlling shock and hemoconcentration has been borne out. The simple first aid formula devised by one of us (H N H) gives quantitative data concerning plasma dosage which compare favorably with those obtained from blood concentration studies. When these latter are available, the simple rule to give 100 cubic centimeters of plasma for every point the hematocrit is above the normal of 45 yields results that are therapeutically as accurate as the more complicated formulas of Black and of Elkinton, Wolff, and Lee. Since the first aid formula indicates immediately the total amount of plasma needed, this had better not be given too fast and should be divided roughly as follows: one-third the first 2 hours, one-third the next 4 hours, one-third the next 6 hours.

Use of the status of the peripheral circulation as a guide to regulate plasma administration as recommended by Rhoads and associates (1942) is also advisable. This should be done especially when the various formulas indicate that large amounts are necessary. Administration of plasma as slowly as is consistent with maintaining the peripheral circulation is the conservative thing to do until the value of plasma is proved in a large series of cases. Although we are sure that in our 2 fatal cases death would have come much

sooner if plasma had not been given, we still cannot say that plasma prolonged their lives. Aside from this slight element of uncertainty, the use of plasma seems to be the best thing for a severe burn patient in shock.

Besides its use in controlling burn shock, plasma has a definite place in controlling the hypoproteinemia which results late in the course of burns and which interferes with healing and the taking of skin grafting. This aspect of the subject has been discussed elsewhere by one of us (H N H, 1942).

### CONCLUSIONS

- 1 Plasma is the best available agent for the treatment of burn shock.
- 2 The administration of plasma should be quantitatively adjusted to fit the patient.
- 3 There are 4 methods of calculating the plasma dosage. When no laboratory facilities are available, use of the *first aid formula* is suggested, whereby 50 cubic centimeters of plasma is given for each per cent of the body surface (as calculated by the Berkow method) involved by a deep (blistering) burn.
- 4 The 3 other methods of calculation of plasma dosage depend on the determination of the extent of hemoconcentration. The formulas of Black, and of Elkinton give accurate results, but the method described in this paper is therapeutically just as reliable and is much simpler. This method is as follows: *the amount of plasma needed can be roughly calculated for an average-sized adult as being 100 cubic centimeters plasma for every point the hematocrit exceeds the normal of 45, as long as the plasma proteins are above 60 grams per 100 cubic centimeters.* When the plasma proteins are below 60 grams per 100 cubic centimeters, an additional 25 per cent of the calculated amount of plasma should be added for every gram the protein level is below 60.

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# THE BLOOD VESSELS OF THE FEMALE PELVIS IN RELATION TO GYNECOLOGICAL SURGERY

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**I**N continuing a study of the anatomy of the female pelvis and peritoneum the authors have become increasingly aware of the part played by the blood vessels in the support of the pelvic viscera, particularly the uterus and vagina. The abundance of vessels in the region of the Mackenrodt ligaments is so great that in well injected specimens the total bulk of the vascular elements seems to surpass that of the tissues in which they are imbedded. The vessels are prominent not merely in the parametrial substance, they also form an appreciable fraction of the fascial tubes of the viscera as well as of the ligaments and the urinary bladder. Moreover, the vessels, and the nerves as well, are disposed in regular strata as they course from source to area of visceral termination.

The drawings of the dissections herewith presented may profitably be examined in connection with illustrations in an earlier contribution on the subperitoneal tissues of the female pelvis.<sup>1</sup>

The dissections were carried out in planned serial order in a selected specimen, each drawing is an accurate representation of a stage in the dissection.

## OBSERVATIONS AND DISCUSSION

From the anterior division of the hypogastric artery arise the umbilical artery together with its superior vesical branches, the uterine, and the middle and inferior vesical arteries.

*Vesical arteries* In the specimen illustrated there are four vesical arteries derived

from the patent proximal part of the obliterated hypogastric (umbilical) artery. They lie in the wing of subserous tissue which passes from the bladder to the pelvic brim.<sup>2</sup> It is a characteristic of pelvic structure that leaf-like formations of fibrous tissue serve as shelves for transmission of visceral vessels and nerves as well as for visceral support. It is as if all of the adventitious tissue of the several vessels were spread out in a continuous sheet to cover the layer of vessels.

Although the superior vesical arteries are multiple, they course, on each side, in a group, toward the point of meeting of the posterior and lateral margins of the bladder. The arteries follow the ureter, resting upon it and paralleling its course on each side. The vessels reach the base of the bladder opposite the line of junction of body and cervix of the uterus. En route they do not send branches to parietal or diaphragmatic musculature.

Upon reaching the bladder they turn medialward, follow a tortuous course within the musculature and ultimately anastomose with the vessels from the opposite side (Figs 1, 2 and 5). The most anteriorly situated of the superior vesical arteries send branches to the superior vesical artery, bringing visceral and muscular ramus into direct communication—a fact important in accounting for the subserous spread of pelvic infection.

*Ovarian artery and veins* The ovarian artery and its accompanying plexus of veins enter the pelvis in company with the ureter as the latter crosses at the bifurcation of the iliac. The ovarian artery, which runs parallel with the ureter for some distance, is evidently sometimes confused by surgeons with the ureteric artery, the latter is exceedingly small and is found on the wall of the ureter.

<sup>1</sup>See Figs 1 and 2 Curtis, Anson, and Beaton, 1940

From the Department of Obstetrics and Gynecology and the Department of Anatomy (Contribution No. 371) Northwestern University Medical School, and from the Illustration Studios University of Illinois.  
<sup>2</sup>Curtis, A. H., Anson, B. J. and Beaton, L. F. Surg. Gyn. Obst. 1940 70 643

Between the layers of the broad ligament the artery courses to the mesovarium (Figs. 1 to 3) within the latter it anastomoses at each extremity of the ovary with a branch sent upward from the uterine artery. Twigs are sent to the fallopian tube and round ligament.

**Ureteric artery.** Upon entering the pelvis the ureter courses downward and forward with the hypogastric artery. Within the broad ligament the ureter passes beneath the bifurcation of the uterine artery (Fig. 3).

The ureter is contained in the tissue which houses the numerous vesical vessels and the autonomic nerves to the bladder. Altogether the arrangement suggests that of a modified pedicle. The structures are grouped at the margin of the uterus, which organ they must pass to reach the bladder. They produce no elevation of the peritoneum. In addition to minute radicles which are sent to the ureter from the cluster of arteries which surround it, the ureter also receives a vessel of fair size from the hypogastric (Fig. 3).

**Uterine and vaginal blood vessels.** Beneath the peritoneum of the posterior layer of the broad ligament the vessels are covered by a thin layer of subserous connective tissue which houses the autonomic nerves of the pelvic and uterovaginal plexuses (Fig. 3).<sup>1</sup> Next below the nerve bearing connective tissue layer and supported by delicate continuations of it, there is encountered a heavy layer of veins. Upon removal of these, the uterine artery is seen well exposed, intermingled with a deeper stratum of veins provided with a minimal amount of connective tissue lateralward in the midst of these veins lies the ureter (Fig. 4).

The uterine arteries in the dissected specimens were even more relaxed and tortuous than is evident in the illustrations, where the uterus is held under tension—a feature of clinical interest in emphasizing the fact that these vessels may be held under tension without notable hazard during radical hysterectomy.

In the specimen illustrated, the uterine artery divides on the left where it crosses the ureter; on the right it also divides, but somewhat nearer the uterus (Figs. 1 to 4). Since

branching of the uterine artery has been found to be common in dissected specimens, similar instances have been noted clinically. Branching of this sort may account for the occasional spurting of a uterine artery when the surgeon is convinced that it has already been carefully clamped before division.

The uterine vessels exhibit a pedicle-like arrangement at the lateral margin of the viscera (Figs. 3 and 4). The arteries divide en route and again near the uterus to surround both surfaces, meeting their fellows of the opposite side. The set of arteries extends through two-thirds the height of the broad ligament. At the level of the vagina the descending branch of the uterine artery anastomoses with the inferior vesical (vaginal) artery (Figs. 1 and 2).

Within the broad ligament the veins are numerous and are arranged in a group with little connective tissue between adjacent vessels. The lowermost vein lies slightly above the uterosacral ligament.

In conformity with observations presented in previous papers concerning the structure of the cellular tissues within the broad ligament, the upper (fallopian tube) region, which is thin and contains very little cellular tissue, also houses very few veins, whereas the Mackenrodt portion of the broad ligament contains a wide expanse of closely interwoven vessels. Immediately inferior to this latter set of vessels, and still within Mackenrodt's ligament, are the ureter and the ureteric and vesical arteries and veins (Figs. 1 to 4).

**Hemorrhoidal arteries.** The deepest vascular level is that of the hemorrhoidal vessels. The superior hemorrhoidal artery descending into the pelvis, divides into four principal branches. The proximal two course along either side of the rectum giving off many small rami to its wall (Figs. 5 and 6). The distal two pass along the superior surface of the pelvic diaphragm, behind the rectum, one on either side of the midline; these two give branches to the rectum before reaching the anal canal. The laterally directed branches of all four divisions anastomose with branches of the middle hemorrhoidal in the wall of the rectum as it reaches the pelvic diaphragm. The anastomoses occur at a point farther anterior than would be expected, i.e. beneath the vaginal canal (Fig. 5).

<sup>1</sup> Report upon the form, distribution and branches of the pelvic autonomic plexuses will appear in an early issue of this journal. R. J. Carter, B. J. Anson, and F. L. Ashley.

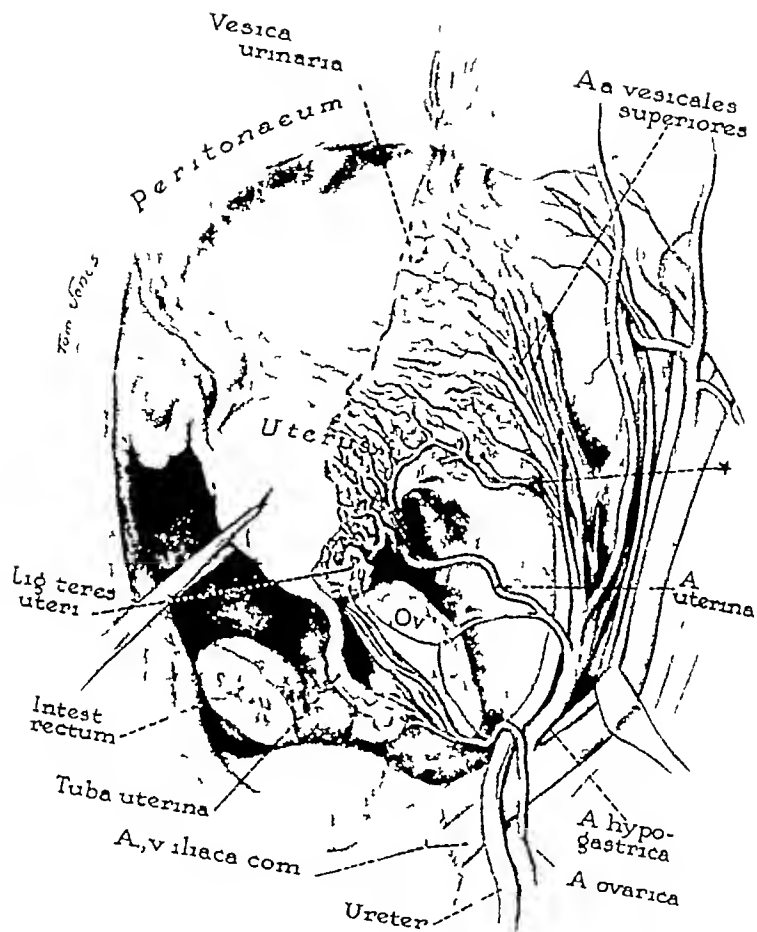


Fig 1 Vesical, uterine and ovarian arteries of superficial level, anterior part of pelvis, uterus retrodisplaced under traction toward left. The peritoneum has been almost completely removed on the right. On the same side, the lateral wing of tissue has been dissected and the veins removed to expose the contained vesical arteries, the lateral umbilical ligament, the ureter and the obturator artery and nerve. The star indicates the vaginal artery, which corresponds to the inferior vesical artery of the male.

*The Blood Vessels of the Female Pelvis in Relation to Gynecological Surgery—  
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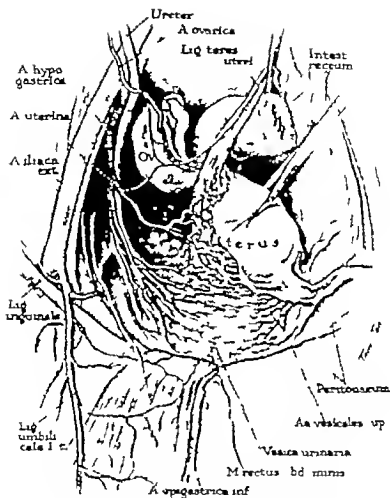


Fig Dissection extended to left, the uterus retracted toward left side. Superior view. Arteries retain their position; the terminal ramus of the celiac arteries has been more completely exposed, bilaterally than in figure

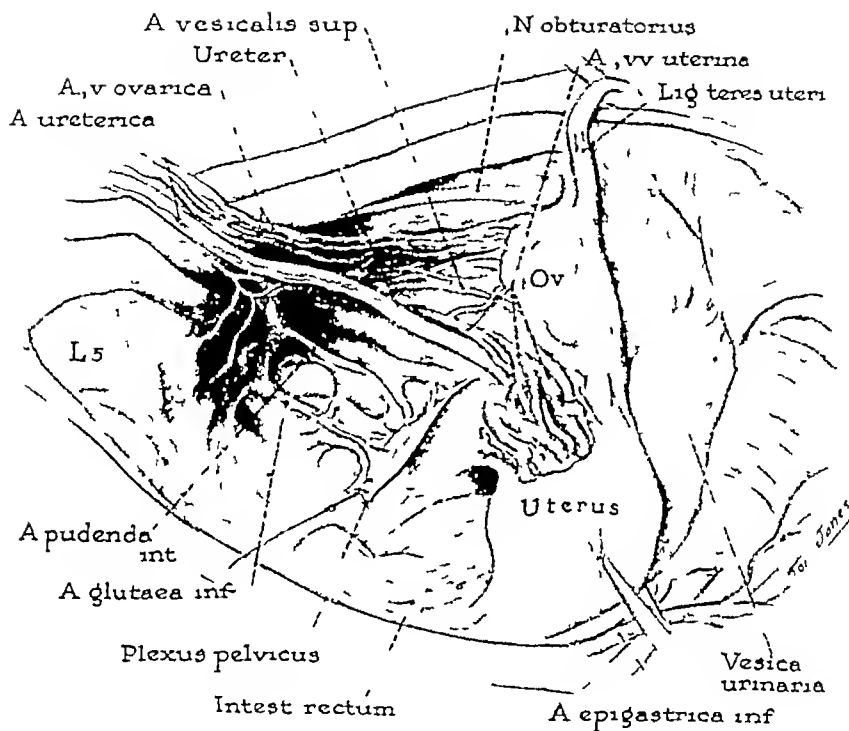


Fig 3 Arteries and veins of posterior part of left pelvis, uterus retracted to right. The peritoneum and retroperitoneal tissues have been removed from the posterior part of the left broad ligament and from the lateral wall of the true pelvis, thus exposing the vessels. The connective tissue containing the pelvic plexus of nerves has been partially freed and retracted by a hook toward the midline. The parametrial tissue has been removed carefully, the structures maintained in their natural positions, all relations carefully preserved.



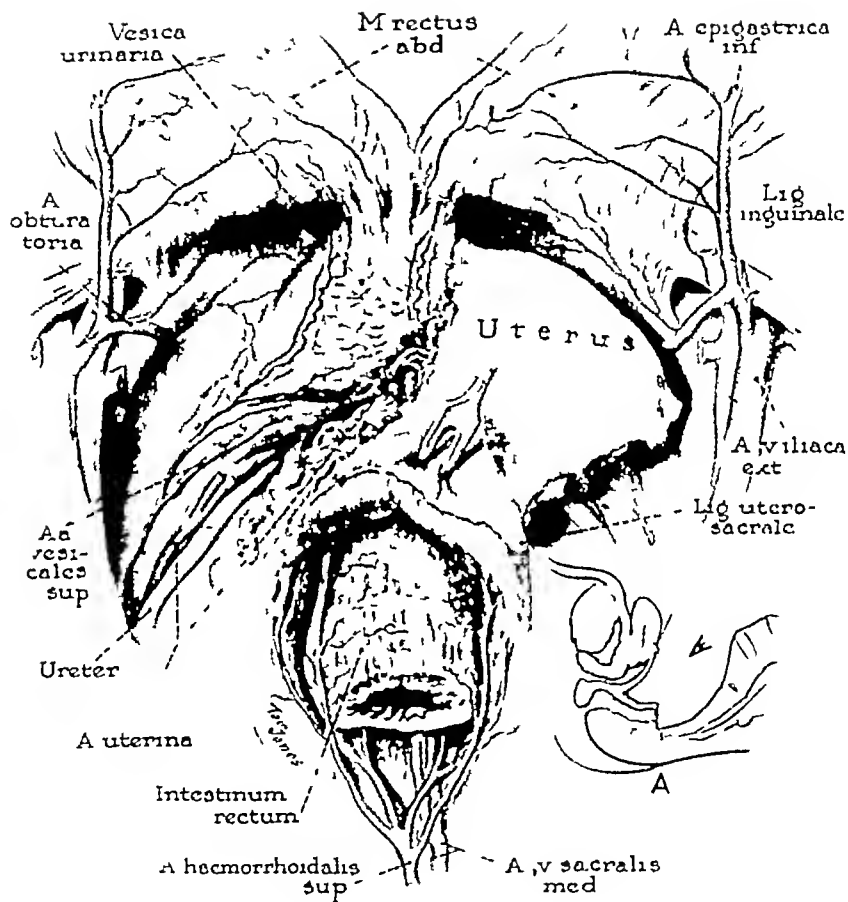


Fig 5 Arteries of superior surface of bladder, of uterine "hilus," and of terminal rectum, uterus has been drawn forward and toward the right. The uterus is covered with peritoneum over its posterior surface down to the level of the cul de sac, the vessels have been cut along its lateral aspect and shown as constituents of a pedicle. On the left the tissue of Mackenrodt's ligament has been removed postero laterally to vaginal level (at star) this is the plane of division between vesical and uterovaginal vessels. The superior vesical arteries have now been traced to the posterior surface of the abdominal wall. The rectum has been cut to the level of the fourth sacral segment, the hemorrhoidal arteries exposed as they course along its posterolateral aspect. Arrow in inset records direction of view in main figure.



# RESIDUAL LESIONS OF ULCERATIVE GASTRITIS

## Possible Relationship to the Development of Carcinoma of the Stomach

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IF the enigma of cancer is to be solved satisfactorily, its pathogenesis must be studied more critically than has been done in the past. The concept that cancer arises from the abnormal proliferation of a single cell which assumes aspects of malignancy from the start and goes on rapidly to the development of a dangerous tumor may be correct. However, many indications point to the suspicion that in some tumors, at least years and even decades of preparation may have preceded the appearance of actual malignancy. Studies of polyps of the colon and small tumors of the cortex of the kidney suggest the long period of evolution through which these tumors proceed before clinical manifestations are apparent.

Although the influence of advancing years and hereditary tendencies undoubtedly are factors in releasing the inhibition to unrestrained growth they probably do not constitute the entire causative background. For many years investigators have debated long and earnestly the pathogenesis of carcinoma of the stomach. It is possible that during this debate the significance of changes in the gastric mucosa which take place over a period of many years has not been stressed sufficiently. Therefore, the present study has been undertaken to evaluate, if possible, the relationship of such changes to the development of carcinoma of the stomach.

### REVIEW OF THE LITERATURE

The association of gastric carcinoma with pre-existing gastric changes is by no means a new concept. For many years certain investigators have focused attention on a variously defined condition called chronic gastritis. Friedenwald, Morrison, and Morrison recalled

that as early as 1878 Lebert found varying degrees of inflammation at remote sites in carcinomatous stomachs. At necropsy of 49 such stomachs, only 5 revealed intact mucosa, 17 displayed some form of gastritis surrounding the carcinoma, 24 exhibited extensive, diffuse gastritis with hypertrophy.

Gastritis is mentioned frequently in the literature but the term has been abused for many years, especially by clinicians. For a time it fell into disrepute probably because of unfavorable comments by certain investigators. Postmortem changes and varying degrees of autolysis were commonly noted. Critics were perplexed by the inconsistency of the pathological reports. In many clinics, pathologists even refused to recognize gastritis as an entity.

In more recent times, revival of interest in, and stimulation to further study of gastritis have been occasioned by the advances made in gastroscopy. Newer instruments, especially of the flexible type, have provided an improved method of visualization. It will be remembered that an important precursor of this method was recorded by the surgeon, William Beaumont, in his classic observations of long ago.

In 1927 Steinberg reported his careful study of 20 resected stomachs. Three of these were ulcerous, 8 were carcinomatous. The specimens had been placed in a bath of two parts of 80 per cent alcohol and one part of formaldehyde immediately after resection. Discussing the carcinomatous stomachs, he described what he considered a precancerous mucosa to be: (1) the glands were irregular, disclosing some cysts, heterotopia, and hypertrophy; (2) the tubules and alveoli were larger and more numerous than those of the normal stomach; and (3) the lining cells of the tubules were larger, high columnar, lightly stained, and had nuclei at their bases. Steinberg con-

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Acceptance of thesis submitted to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Surgery.

cluded therefrom that gastritis was marked in carcinomatous stomachs

In the same year, Faber (4) presented his paper on the sequelae of gastritis. He stated that the end-result of the disease was rarely complete mucosal atrophy and achylia and that the development of gastritis itself was slow and irregular. According to Faber, the form can be preserved and function may return if opportunity is presented. Complete atrophy, Faber thought, resulted only after many years of disease. The incidence of gastritis was therefore quoted as being much higher among old than among young people.

In 1929, Hurst (8) wrote that he considered gastritis to be the most common lesion predisposing to carcinoma of the stomach. In 75 per cent of his cases of gastric cancer the disease was said to have begun in chronic gastritis. "the achlorhydria is a result of chronic gastritis, which precedes the onset of the carcinoma," he wrote, "I have never seen a case of carcinoma in which free hydrochloric acid was present at an early stage and disappeared as the disease advanced."

Hurst stated that, in the presence of gastritis, the gastric glands were plugged by mucus and the gastric juice was dammed back. This reverse pressure was presumed to inhibit further secretion. Therefore, he reasoned, further irritation should open an easy avenue to infection, especially by streptococci. The mucosa was said to thicken, then atrophy. Achylia was the result, recovery to a certain point was known to be possible, but Hurst realized that the atrophied parietal cells would never be replaced. He pointed out that friction is as important in the causation of cancer in any other portion of the body. Since friction is most pronounced near the pylorus, the irritation arising from it was held to be responsible for the high incidence of cancer in that region as compared to the incidence of cancer in other portions of the stomach.

After brilliant research on the problem of pernicious anemia which resulted in such effective therapeutic control, many investigators anticipated a resultant higher incidence of gastric cancer, since atrophic gastritis consistently afflicts patients having pernicious

anemia. By application of the new therapeutic measures, patients' life expectancies were appreciably increased. In 1931, Plummer and Simpson (12) reported on a patient who had had Addison's anemia and who, 5 years after that condition was discovered, died of carcinoma of the stomach. The lesion was situated at the pylorus, on the lesser curvature of the stomach, and was of the annular type. Viewed in microscopic preparation, excess mucus with no oxyntic cells was seen 3 inches (8 cm) from the margin of the lesion. Closer to the lesion there was more and more "mucoid degeneration." The malignant cells also were loaded with globules, the glandular fundi were dilated, cystic, and lined with low, atrophic cubical epithelium. Many foci of lymphocytes were seen close to the glands.

Plummer and Simpson commented on the sudden change at the margin of the lesion from tissue characterized by atrophic gastritis to a region of malignant, spheroidal cells. These were closely packed, devoid of any acinous formation, and contained excess mucus within the cytoplasm. The investigators noticed the absence of an inflammatory cell reaction and of fibrosis in the periphery of the lesion, and they pointed out that this observation had been the factor which distinguished such lesions from the general changes seen in specimens of peptic ulcers.

In 1934 Henning's book appeared. In it he discussed the relationship of changes in the gastric mucosa to the development of gastric carcinoma, stressing the feeling that gastritis had not received enough attention in this light in the past. He stated that although the question of whether the inflammation was primary or secondary remained to be answered, detection by Konjetzny and Saltzman of gastritis in specimens of cancer had to be given prime consideration. He was convinced that Ménétrier, Nauwerck, Verse, and other investigators had demonstrated the connection between gastritis and malignant tumors.

Henning credited Hauser, Ménétrier, Lubarsch, Verse, and Konjetzny with demonstrating that the atypical gastric gland and epithelial elements, preceded by the chronic inflammation, followed atrophy within the structure of the stomach. Henning recalled

that on the basis of microscopic study of tissue affected by chronic gastritis, the ostensible site of origin of the malignant degeneration was in the luxuriant overgrowth of the lining epithelium, as well as in the heterotopic glands.

Henning quoted Orator's observation that the gastritis associated with cancer was of the atrophic type and that it was spread diffusely throughout the entire stomach in contrast to the type of gastritis accompanying peptic ulcer in which it was circumscribed and more frequently than not confined to the pyloric antrum. Furthermore, Henning wrote Konjetzny had pointed out that the peculiar distinction of the gastritis associated with carcinoma was the excess activity of mucus-producing cells (in contradistinction to the more acute and subacute inflammation accompanying the usual type of peptic ulcer).

Henning held that evidence of atrophy was observed in specimens of tissue affected by carcinomatous gastritis, although the atrophy was not so diffuse or extensive in some cases as it was in others. The significant changes in the mucosa were disclosed by the remaining glandular cells. Hand in hand with the loss of specific epithelium, regeneration was detected as operative within the mucus-producing cells. Therefore, the most spectacular characteristic change observed in Henning's sections of mucosa affected by gastritis accompanying carcinoma was the luxuriant overgrowth of the lining epithelium. The shapes of the thick lining cells varied from round to polygonal. The nuclei appeared to have migrated to the bases; pyknosis was a common characteristic. At times, mitotic figures were seen. A prominent change was the piling up and thickening of the basement membrane. This scarcely had been mentioned before the emphasis accorded it by Konjetzny.

Henning concluded that the pathological picture was heterotopia of the gastric glands, overgrowth of the interstitial network, and "infiltration (mostly by lymphocytes but also by plasma cells). In some cases, the greatest change occurred in the immediate vicinity of the tumor but in any event the most pronounced gastritic lesions were seen in the carcinomatous mucosa.

Early in 1935 Simpson analyzed 53 specimens taken for biopsy from carcinomatous stomachs. Varying degrees of gastritis were seen in all the specimens and suggested to him that the condition preceded rather than followed the cancer. Nearly all the specimens of gastric tissue exhibiting well developed atrophic gastritis he had ever seen had come from carcinomatous stomachs. In those instances in which the cancers were held to be secondary to the formation of ulcers, the gastritis was much less severe and was restricted to a region close to the edge of the tumor. Fifty per cent of the cancers were associated with some free acid; all the "ulcer-cancers" were associated with free acid.

Faber followed the course of the term "gastritis" through its early acceptance as a diagnosis and its later abuse and disrepute. His thorough and clarifying reports have done much to re-establish proper consideration of the condition of the term. In 1935, he (5) reported that by the intra-abdominal injection of from 400 to 500 cubic centimeters of a solution of 10 per cent formalin immediately after the death of patients, good fixation was realized. The specimens thus prepared were free from postmortem gastromalacia and destruction of the gastric epithelium. Faber clearly described two types of gastritis as encountered pathologically, namely the erosive type and the chronic diffuse type. He observed that cysts might form in the crypts; lymphocytic aggregations near the pylorus in chronic cases led to the adoption of the term chronic follicular gastritis. Hypertrophy of the surface epithelium and that of the epithelium of the crypts might raise folds and warty protrusions (polyps) which constitute a form of end product of the atrophic inflammatory process. In most places, Faber said, metaplasia occurs the surface epithelium, formerly typically gastric, is transformed into goblet-cell epithelium. The gland-bearing region then resembles a gland-bearing region of the small intestine. Faber pointed out that the final stage of chronic gastritis may be pronounced atrophy of the mucosa.

Concerning the relationship of gastritis to achylia, Faber declared that anacidity is usually the result of a disturbance of the mucosa,

a disturbance which is gastritis in some form. The scale of anacidity corresponded well with the range of anatomical changes, and it was not considered a constitutional defect. Hereditary and constitutional factors were said to enter only as they affect the power to ward off gastritis. Faber concluded that "cancer is always accompanied by gastritis." He suggested that regenerative changes might be of pathogenic importance. He stressed the point that no matter what other factors enter the discussion, predisposition to cancer in the form of heredity and constitution cannot be overlooked.

In 1936, Duplant published results of histological studies of the carcinomatous gastric mucosa made at varying distances from the edge of the tumor. He found that both close to the edge of the lesion and at a distance from it there was tissue involved by superficial and deep gastritis with layers and islands of round cells. Neoplastic cells were not seen at a distance, the tumor seemed limited to the carcinomatous region. Varying degrees of intensity of inflammation were observed in tissue from various stomachs and this inflammation was obvious at a distance from the tumor.

Hurst (9) then declared that he considered gastritis to be the only common primary disease of the stomach, he said that "the prevention of gastritis would mean the prevention of chronic gastric and duodenal ulcer and of cancer in the stomach." He held that if the stomach were protected from the "extrinsic factors" of alcohol and dietary abuse, carcinoma would not develop. The "intrinsic factors" were said to be hereditary and constitutional factors. He was certain that gastritis produces achlorhydria and that it also produces carcinoma. He repeated the contention that gastric cancer might be expected to develop among many patients having pernicious anemia, since the life expectancy of patients with the latter disease has been prolonged. He concluded that cancer never develops in a healthy stomach.

Also in 1936, in a review of 158 resected carcinomatous stomachs, Tuomikoski outlined the conditions most suggestive of atrophic gastritis acting as the primary disease, mucosal changes were no more prominent

close to the edge of the carcinoma than they were at a distance from it, the incidence and intensity of gastritic changes were independent of the nature of the carcinoma, such marked changes obviously required a long time to develop. Tuomikoski concluded that "Most carcinomas of the stomach probably arise on the basis of a chronic atrophic gastritis."

Baker approached the problem from its chronological aspects in the antrum of the stomach, the early changes were increase in stroma and addition of lymphocytes, later, lymphocytes gathered in the form of follicles, still later, atrophy appeared in the specific epithelial cells, and at times there was apparent hyperplasia of the epithelial cells. In cases in which the process was more advanced, the epithelium had the appearance of intestinal epithelium, with "goblet cell metaplasia," as European workers called it. In all cases the muscularis mucosae appeared thickened by fibrosis and hypertrophy, and lymphocytes frequently were present. In the corpus the changes were as described, and the dominant feature was atrophy, partial and sometimes complete, of the chief and parietal cells.

In 1937, gastroscopy entered into wider use. The types of gastritis recognized by Schindler, Ortmayer, and Renshaw were superficial, atrophic, and hypertrophic. They concluded that gastric carcinoma might follow the atrophic type of gastritis.

In the same year, one of the most significant of all these analyses made its appearance. Comfort, Butsch, and Eusterman reviewed observations made of 79 patients having carcinoma of the stomach for whom gastric analysis had been carried out before the clinical appearance of carcinoma. Of these, 30 patients (38 per cent) had had achlorhydria at the time of the original aspiration. Forty-seven patients (59 per cent) had suffered from cancer of the stomach within the next 5 years and 20 more within the next 5 years.

These authors stated that "The process responsible for the reduction of gastric acidity attacks the mucosa in some cases but not in others." They favored the hypothesis that destruction had occurred in the secreting cells previous to malignant changes. This process

probably had the nature of gastritis. Quoting Baker who had examined tissue from patients who underwent gastric resection, they reported (1) in the stomachs having no free acid at the first aspiration, the mucosa of the upper antrum and lower corpus disclosed marked atrophic gastritis and very few acid-secreting cells (2) in the stomachs with free acid present at the original aspiration but none at the second test the mucosa of the upper antrum and lower corpus disclosed moderate or marked gastritis and only a few acid-secreting cells and (3) in the stomachs with some free acid present at all aspirations, the mucosa revealed slight to moderate gastritis. Three stomachs had normal mucosa.

Comfort and his co-workers believed that it was conservative to claim that the loss of gastric acidity usually took place before the onset of malignant neoplasm.

In 1939, Robertson presented a paper in which many ideas were crystallized. Previously he had concluded that the most frequent lesion in the superficial layers of the mucosa of the stomach was hemorrhage. In 1939 he elaborated on a possible subsequent course of the hemorrhage. Hemorrhage was said to lead to necrosis, and digestion of the necrotic region to ulceration. Ordinarily he wrote the ulcerated regions heal completely. Grossly the mucosa may seem to be restored but in some instances microscopic examination reveals residual lesions in it. These he listed as collections of lymphocytes in the mucosa, irregular thickening and fibrosis of the muscularis mucosae atrophy of the chief and parietal cells, hyperplasia of the mucous cells, and disorganization of glandular elements.

Robertson anticipated two main objections to his list. First would be the question what is the significance of the lymphocytes does each collection represent an old ulcer? To this he replied that facts at his command insufficiently supported such an assumption. Second would be the question what of other causes of ulceration, such as embolism and thrombosis. He stated that there is no fundamental difference that the first lesion in most cases of gastric ulcer is hemorrhage from the capillaries of the mucosa. The disintegration and necrosis are merely subsequent develop-

ments. One of the conclusions reached is that the hyperplasia of the mucous glands may have some relation to the development of carcinoma.

Robertson's work throws new emphasis on early individual deviations from the normal state within the gastric mucosa. Many other workers have added valuable isolated contributions to the study but the majority of the investigations centered upon or took issue with gastritis. Long standing lesions of the gastric mucosa have been neglected. The greater share of the research has not been initiated at the primary point of importance.

#### MICROSCOPIC INVESTIGATION

The aim of the present study was to investigate the residual lesions present in the gastric mucosa long before gastritis as described by some authorities could be diagnosed.

*Material* The material examined consisted of specimens from 300 carcinomas of the stomach removed at operation, percutaneous both. The patients were encountered at the Mayo Clinic between 1926 and 1938. Their average age was 58.7 years the youngest was 16 years old and the oldest 83 years. There were 154 males and 46 females.

Sections made for microscopic examination were divided into two series. The first series consisted of sections taken directly through the carcinoma and is designated *tumor series*. The second group of specimens was cut at a standard distance of 10 centimeters from the edge of the tumor and is designated *remote series*.

As a control 78 average stomachs were examined. These were obtained at the routine postmortem examination of patients who had been known not to have carcinoma of the stomach. Since the majority of specimens in the series concerned with carcinoma came from patients who were more than 35 years of age, the age of 35 years was taken arbitrarily as a dividing point. Thirty-nine specimens in the control group came from patients who were more than 35 years old. Their average age at death was 55.3 years. Twenty-eight were males and 11 were females. This subgroup is designated the *comparable-age control series*.

The other 39 specimens came from patients who were less than 35 years of age. Their average age was 18.2 years. Twenty-two were from males and 17 from females. These are to be known as the "younger control" series.

**Method** Since the residual lesions mentioned previously are those most constantly observed in the diseased gastric mucosa, that list was employed herein as a thorough and convenient criterion for estimation of previous change. This list has been modified in regard to the muscularis mucosae. It was noticed that thickening, irregularity, and fibrosis of the layer might occur singly or in various combinations. Therefore, for convenience in tabulation, the residual lesions were placed in seven separate columns: (1) lymphocytes, (2) irregularity of muscularis mucosae, (3) thickening of the muscularis mucosae, (4) fibrosis of the muscularis mucosae, (5) atrophy of the chief and parietal cells, (6) hyperplasia of the mucous cells, and (7) disorganization of the mucosal glandular elements.

All the microscopic sections were examined from the standpoint of this list. The degree of the change observed was tabulated on the usual grading scale of 1 through 4, in which 1 indicates the least, and 4 the greatest, change.

**Results** In the 200 cases of carcinoma not one case could be placed entirely outside the seven columns of classification, although a few sections cut through the tumor revealed little evidence of the lesions. Likewise, all the specimens of the remote series contained evidence of at least one of these lesions. At the same time, the comparable-age control series had only 1 completely free member. The younger group contained 4 such instances.

When the final tabulations of the grades of change were examined closely it became apparent that certain of the "residual lesions" could not in themselves be regarded as of prime significance in the development of the carcinoma. To elaborate, the most common change in all specimens, whether cancer or control, was the accumulation of lymphocytes in the mucosa, either in so called follicles, or in diffusely scattered array. There was no consistent relationship either as to number or degree, and it is true in this regard as well as

in the study of any tissue that adequate proof of the exact significance is lacking. Then, too, part of the observed irregularity and thickening of the muscularis mucosae was seen to be secondary to the presence of the carcinoma in many sections. These two changes, associated with fibrosis of the muscularis mucosae, also were rather common in the noncarcinomatous control stomachs, especially of the comparable-age group. "Disorganization" was obviously too nonspecific.

The evidence obtained by tabulation of the grade of change in the 5 residual lesions considered of secondary importance in the pathogenesis of carcinoma was later found to be invaluable in the study of chronicity of disease, of which more will be said hereafter. This leaves for serious primary consideration only two of the residual lesions, namely, (1) atrophy of the chief and parietal cells, and (2) hyperplasia of the mucous cells.

**Frequency of the lesions** Atrophy of the specialized epithelial cells was an extremely frequent and consistent observation in the cancer group, both in the sections made directly through the tumor, 98.5 per cent, and in those cut at the standard distance of 10 centimeters from the edge of the cancer, 91.5 per cent. Only a slightly less frequent appearance of hyperplasia of the mucous cells was recorded in these two groups, 89.5 and 83.5 per cent respectively. On the other hand, in the control groups, these findings were much less common. Atrophy in the comparable-age group was only 66.6 per cent, and in the younger control group 48.7 per cent, hyperplasia in the comparable-age group was 33.3 per cent, and in the younger control group 30.7 per cent.

**Prominence of the lesions** The comparative degree of severity of change was next examined on the grading scale of 1 through 4. To eliminate all questionable factors, such as slight or debatable change, personal bias and other possible elements, a separate tabulation was drawn up to demonstrate only the significant degree of change. The incidence of atrophy of special cells of grade 2 plus or higher was 81 per cent in the tumor series, 58 per cent in the remote series, 25.6 per cent in the comparable-age series, 12.8 per cent in the younger control

series. The incidence of hyperplasia of mucous cells of grade 2 plus or higher was 44 per cent in the tumor series, 35 per cent in the remote series, 57 per cent in the comparable-age control group and 51 per cent in the younger control group. The fundamental differences between carcinomatous stomachs and control stomachs as brought out by this study are summarized bluntly. To obtain a complete view of the prominence of the significant residual lesions, the average degree of change by grades was computed on the numerical basis as follows: atrophy of special cells graded 3 minus in the tumor series, 2 plus in the remote series, 1 in the comparable-age control group, 1 minus in the younger control group; hyperplasia of the mucous cells graded 2 in the tumor series, 1 plus in the remote series, 1 minus in the comparable-age control group and a little above 0 in the younger control group.

*Atrophy and regeneration.* On the numerical basis it would appear highly important to consider the hypothesis that the process of atrophy of the chief and parietal cells initiates an attempt at repair in the form of hyperplasia of the mucous cells. Apparently control of this hyperplasia is lost and malignant growth results. The consistently higher grade of hyperplasia in specimens from the tumor series compared to that seen in the remote series of specimens from the same stomachs is interpreted to imply that at some time a definite change from the process of simple hyperplasia to that of actual carcinoma occurs. The consistently lower incidence and markedly less prominent degree of hyperplasia in the control groups lend support to the conclusion that hyperplasia (regenerative activity) is a highly important factor in the pathogenesis of carcinoma of the stomach.

*Gastric acidity.* The many references in the literature to achylia and its possible importance together with the conclusions of Com fort, Butsch, and Eusterman concerning gastric acidity before and after the development of carcinoma of the stomach, stimulated a similar review in this series. Of the 200 cases of carcinoma gastric analysis was recorded in 124. Of these, in 96 cases (77.4 per cent) there was no free acid. The average amount of free

acid was 5.37 points." The close correlation of this figure with the high degree of atrophy of the parietal cells already recorded is obvious.

Of the 200 cases, in 20 the neoplasm was suspected clinically of originating as a gastric ulcer. Eighteen males and 2 females were concerned. The average age was 57.8 years. Gastric analysis was recorded for 18 free acid was present in every one of these cases. The average free acid was 18.7 points. This so-called ulcer group was separated from the main series temporarily and a comparison of the significant criteria made as follows: atrophy of the special cells graded 3 minus in the tumor series, 1 plus in the remote series; hyperplasia of the mucous cells graded 1 minus in the tumor series, 1 plus in the remote series. Comparison of the figures suggests that the major difference between the entire cancer series and the "ulcer-cancer" group, in regard to degeneration and attempted repair, is the generally lower average grade of atrophy in the remote counterparts of the latter group. If these former ulcer cases could be disregarded it would seem that an excellent clinical indicator of the ability of the stomach itself to ward off the development of carcinoma would be the presence of a normal amount of free hydrochloric acid. Can gastric mucus which is maintaining normal acidity be assumed to sustain no degeneration and therefore to initiate no disorganized attempt at repair? As yet there is no clinical indicator of the status of the mucous cells.

#### EVALUATION OF STUDY

*The time factor.* With reference to those residual lesions which were considered to be of secondary significance in this study it is worth while to regard the control cases from the chronological viewpoint. The stomachs of the patients of infancy and childhood years were found to demonstrate the fewest and least marked residual lesions and therefore were considered to be the most nearly normal. On the other hand, among patients between 30 and 50 years of age varying degrees and combinations of the residual lesions as a rule were observed. Although specimens from some of the oldest patients disclosed very little damage numerous stomachs from patients

past 50 years of age revealed many of the changes, in a very marked degree. It seems conservative to state that the average young person is likely to be more free from gastric changes than is the average old person.

In the younger control group, the observed lesions were usually of the less significant type, they were lymphocytes, general mucosal disorganization and incidental thickening. Atrophy of the special cells and hyperplasia of the mucous cells were rare. The comparable-age control patients revealed much more marked irregularity, fibrosis, and thickening of the muscularis mucosae, with some diffuse atrophy of specialized epithelium. These features all point to a decidedly chronic condition.

In the carcinomatous stomachs, the most significant lesions were those discussed above. In addition to these there was a high degree of change in the muscularis mucosae, arguing for a long standing disease process. These factors had been emphasized previously by Baker and by Robertson. There is a strong suggestion that chronic atrophy of the chief and parietal cells is a persistent stimulus to the production of disorderly hyperplasia of the mucous cells. Faber (5) touched on this when he hinted that certain reparative processes might be of importance in pathogenesis of gastric carcinoma.

The early work of Lebert, later elaborated upon by many others, stressed the importance of a generalized mucosal change. In the present study, the discovery of certain similar, significant lesions in the mucosa 10 centimeters from the edge of the carcinoma suggests that the entire stomach is host to the malignant process. The change is gradual and diffuse and is not a sudden, primary overgrowth. All present observations tend to indicate that the mucosa begins to change long before the actual appearance of carcinoma. It will be recalled that Henning, Steinberg, Tuomikoski, and others held the same opinion. Simpson observed somewhat similar changes which he called "gastritis," and he asserted that the remote counterparts of "ulcer-cancer" cases exhibited much less general change than other types of carcinoma.

Faber (4, 5) commented on the close correlation of gastric anacidity with the observed range of anatomic gastric changes, this cor-

relation agrees with the present observations. Also, the clinical work of Comfort, Butsch, and Eusterman, together with the study from the pathological viewpoint of their cases by Baker, tends to substantiate the general assertions made herein. The fundamental difference between the average carcinomatous stomach and the average noncarcinomatous stomach is the relative lack of mucous-cell hyperplasia in the latter.

It would seem that Hurst (9) expressed much in few words when he declared that carcinoma does not develop in a healthy stomach. Thus far, the most important factors in the development of carcinoma of the stomach appear to be (1) many years of repeated anatomic insults, resulting in residual lesions and disorganization of the reparative processes, (2) age, and (3) heredity.

#### SUMMARY

Review of the literature reveals many attempts to designate gastritis as a precursor of gastric carcinoma.

Residual lesions of ulcerative gastritis are defined as "irregular thickening and fibrosis of the muscularis mucosae, atrophy of the chief and parietal cells, hyperplasia of the mucous cells, and disorganization of the mucosal elements."

A study made microscopically of sections from 200 carcinomatous stomachs and of sections from 78 control stomachs is outlined.

The frequent occurrence of certain residual lesions in carcinomatous stomachs is compared to the occurrence of such lesions in noncarcinomatous stomachs.

Evidence is presented to indicate that essentially similar lesions occurring at a distance from a gastric carcinoma suggest that the entire gastric mucosa has undergone change and that much time has been required for this change to take place.

The fundamental difference between the average carcinomatous stomach and the average noncarcinomatous stomach is the relative lack of mucous-cell hyperplasia in the latter.

#### CONCLUSIONS

Carcinoma develops in a previously damaged stomach.



Many years of such injury may be required before neoplastic transformation begins.

The pathogenesis of gastric carcinoma is directly related to the disorganized hyperplasia of gastric mucous cells.

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# THE SHOULDER JOINT OBSERVATIONS ON THE ANATOMY AND PHYSIOLOGY

With an Analysis of a Reconstructive Operation Following Extensive Injury

LAURENCE JONES, M.D., Kansas City, Missouri

**T**HE primary purpose of this report is to present certain observations which have radically altered our conception of the basic anatomy and physiology of the shoulder joint. This is the result of a combination of clinical experiences checked by anatomical dissection.

These changes have necessitated revision of our ideas concerning etiology, pathology and treatment of diseases which affect the shoulder joint. This shift is not limited to traumatic lesions alone but extends to include many congenital and acquired complexes.

A reconstructive operation for the shoulder joint following fracture or injury about the head of the humerus will be presented not only for the intrinsic value it may possess but as an illuminating experiment in the pathological physiology of the shoulder joint. In short these observations concerning basic anatomy and physiology were made in the course of attempting to explain variable postoperative results.

This procedure was first reported in 1935 (2). At that time it was demonstrated that following resection of the head of the humerus a stable shoulder could still be secured by transplanting the "short rotators" into the upper end of the shaft.

It was to be used following fracture dislocation of the head severely comminuted fractures in this region which defied reduction or when it was necessary to remove the head for other reasons. This original article suffered from an inadequate presentation due to the fact that the author did not understand at that time, these basic principles which seem to govern the shoulder joint. Aside from these considerations, the procedure has been of value in civil practice and should have considerably more use in military surgery.

From the Orthopedic Service, Menorah Hospital

In the belief that interest will be increased by following the chronological development of these ideas the presentation will start with the first case history.

**CASE 1** July 15, 1926 a man engaged in the building trade, aged 67 years, fell a distance of about 10 feet from a scaffold and in so doing struck the left shoulder heavily against a timber. He was immediately taken to the hospital and it was noted that the left shoulder was flattened as compared with the other. Without a preliminary roentgenogram dislocation was diagnosed by the surgeon. He was placed under anesthesia, and a vigorous attempt made at reduction. When deformity was still found to be present, roentgen examination was made and the patient was found to have a comminuted fracture just above the surgical neck with subglenoid dislocation of the head. Six separate fragments could be seen. It was an interesting picture. Now it can be told that it was so interesting that it shortly disappeared, and therefore cannot be reproduced.

Because of the wide separation of fragments there was complete agreement that resection of the dislocated head and fragmented tuberosities was clearly indicated and that without doubt the end result would be a flail shoulder. To avoid this the author agreed to attempt an experimental procedure, which he had been considering for some time.

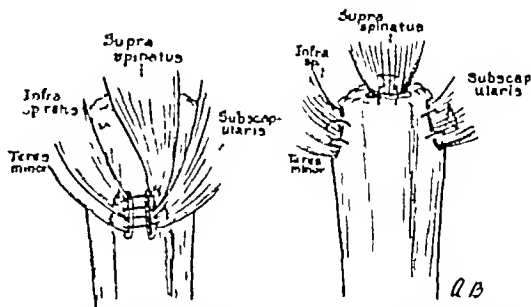


Fig. 1. Illustrating differences in the sites of transplanted capsular muscles that form the basis of the reconstruction that follows resection of the head of the humerus. Left Case 1, typical location that resulted in complete stability, return of normal range of motion with good muscle power. Right Case 2, reposition that followed anatomical description resulting in complete stability accompanied by limited range of motion and decreased muscle power.

Many years of such injury may be required before neoplastic transformation begins.

The pathogenesis of gastric carcinoma is directly related to the disorganized hyperplasia of gastric mucous cells.

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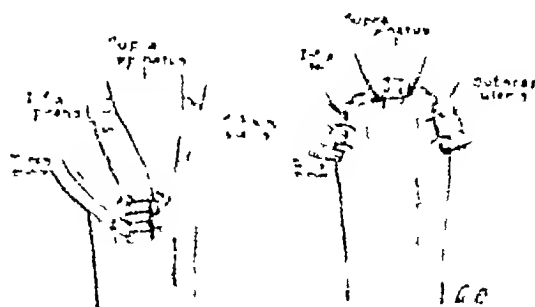
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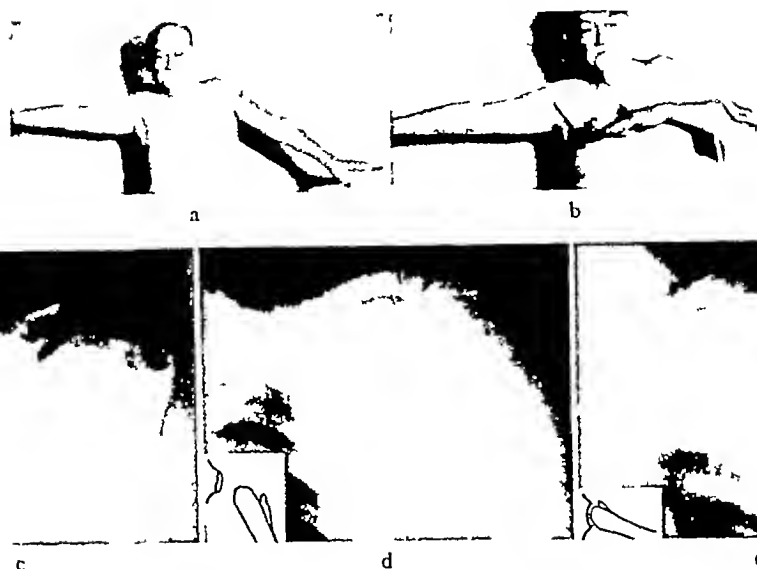


Fig 3 Photographs taken 2 years after operation, a stable shoulder with decreased range of motion, b stable shoulder with only fair muscle power, c original roentgenogram and tracing showing extreme comminution and displacement of fragments, d, roentgenogram and tracing

stability, there was almost a complete restitution of shoulder function.

In the old operation the head was resected without any treatment of the shaft. In the new, certain muscles were transplanted into the upper end of the humerus. Therefore, this procedure seemed to be the difference between two very different end-results, one, a "flail shoulder," the other, a shoulder having excellent function.

In retrospect, it is now seen that the end-result in the first case is all that could possibly have been expected. But this was not seen at the time, as convalescence was slow. To secure a complete range of motion several manipulations were necessary. It was thought that this was due to the fact that the site of the insertion of the transplanted 'short rotators' did not conform to the usual anatomical description. In the next case the sites were changed (Fig 1).

CASE 2. October 16, 1930, the patient, a mechanic for the city water department fell a distance of about 10 feet from a ladder. He believes that he fell directly on the point of the left shoulder. He was 35 years old, not particularly robust, in considerable pain and slightly shocked. The curve of the left

shoulder was flattened as compared with the right and he was unable to move the arm at the shoulder joint. A roentgenogram demonstrated a comminuted fracture of the upper end of the left humerus at the junction of the head and neck. The greater tuberosity was also comminuted. The upper end of the shaft was displaced into the axillary space. Under gas oxygen anesthesia, reduction was attempted. A plaster cast was applied in which was incorporated a metal device for extension of the arm in partial abduction.

The laboratory reported a strongly positive Wassermann with a slight secondary anemia and a moderate leucocytosis. He was immediately given suitable antiluetic therapy.

Other attempts at reduction both by manipulation, increasing traction and changes of splint position, were ineffectual. With supportive measures and antiluetic therapy his general condition improved. November 14, 1930, a resection was performed, similar in all respects to that described for the first case, with a single difference. The 'short rotators' were inserted into the upper end of the shaft to accord with anatomical description: the subscapularis in front, the supraspinatus laterally and the joined tendons of the teres minor and infraspinatus posteriorly.

The postoperative course was somewhat stormy. His secondary anemia became gravely anally resulting, November 25, in a 50 per cent decrease. With blood transfusions and antiluetic therapy his condition rapidly improved. He was discharged from the hospital in January, 1931. In the end he



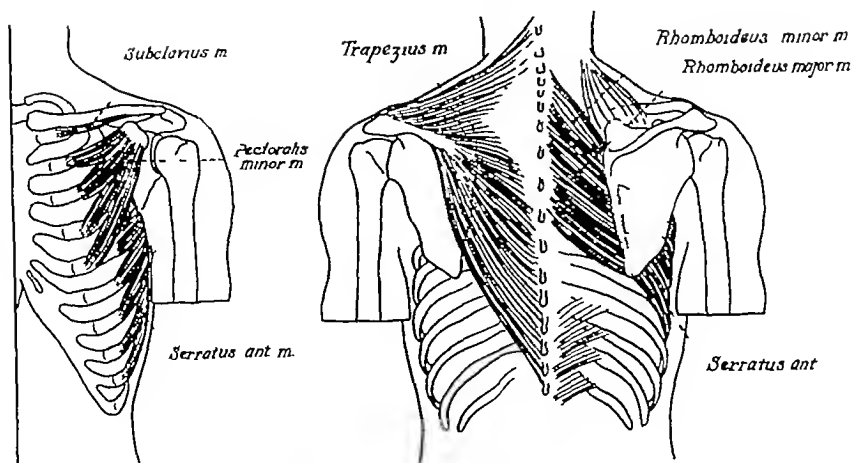


Fig 4 Diagrammatic representation of the muscle groups connecting the clavicle and scapula to the costal cage. These contract synchronously to stabilize the glenoid, during the effort complex. a, left, The anterior group, b, the posterior group

This is effected by synchronization of muscles which cause the scapula and clavicle to be pulled firmly against the costal cage. Once this is accomplished, the glenoid becomes a fixed point. The chief muscles effecting this are the subclavius and the pectoralis minor acting as stabilizers anteriorly, the trapezius, major and minor rhomboids, posteriorly, and the serratus anterior, which acts powerfully on the vertebral border of the scapula, although it originates anteriorly (Fig 4). This combined mechanism resembles the guy ropes of a tent pole in that, if they act simultaneously, they stabilize by counter action.

The second phase of this problem is, namely, stabilization of the articular surface of the head of the humerus, the outer side of the joint, by muscles connecting the scapula and the head. This is accomplished in the presence of severe mechanical disadvantage. That it can be done at all is a triumph of evolutionary adaptation. The upper end of the humerus has become a half spheroid, the "ball" of what is described as a ball and socket joint.

A better description would be that it is a ball without a socket. The fact that the glenoid has become flat, deepened only by a vestigial thin layer of cartilage has been mentioned. All of this is the interest of a completely free range of relaxed motion. But the effort syndrome calls for primary stabilization,

firm fixation of this rounded head in a flat glenoid, and this is accomplished by four muscles, usually described as "short rotators." These are actually three, as two of them function as one. These muscles, listing them from before, backward, are as follows: the subscapularis, the supraspinatus, and the infraspinatus teres minor.

Time does not permit us to detail the differences found in the various textbook descriptions of the anatomy and physiology of these muscles. The variance is so great that the truth must be elsewhere. Therefore, it is not to be wondered at that there are grave misconceptions concerning these points, even among orthopedic surgeons. Before the results of certain experiments are given, these muscles will be described as we have come to see them.

This anatomical controversy is chiefly concerned with the insertion of these muscles and the relation of that insertion to the capsule of the shoulder joint. For example, most of the standard textbooks show plates in which these "short rotator" muscles are attached to small areas or facets on the greater or lesser tuberosities of the humerus. Accompanying texts state that they "adhere to" or are "in intimate contact with" the capsule. This anatomical description that follows will start with the much publicized supraspinatus and will show that there is



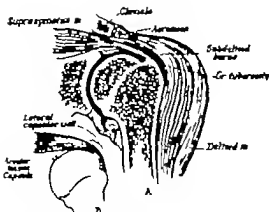


Fig. 5 Diagrammatic cross section illustrating the anatomical interrelation between the head of the humerus, supraspinatus muscle, supraspinatus tendon, capsule, acromioclavicular joint, and the deltoid muscle. A, Enlarged cross section illustrating the fusion of the supraspinatus tendon and the capsule to form a conjoined tendon before final bony insertion.

considerable variation between these descriptions and factual anatomy.

Before this is done it should be noted that close examination of these areas requires the preliminary removal of the deltoid, the clavicle, the entire acromion process of the spine of the scapula, and the point of the coracoid process with the inserting muscles the short head of the biceps and the coraco-brachialis (Figs. 5 and 6).

The supraspinatus is actually much smaller than it is thought to be. It arises in the supraspinous fossa and passes over the upper edge of the glenoid. At a point just external to the acromioclavicular junction it fuses with the capsule to become a conjoined tendon. This conjoined tendon then inserts narrowly into the superior horizontal portion of an inverted U. This inverted U follows closely the margin of the greater tuberosity on the extreme upper lateral surface of the humerus. To simplify surgical anatomy this will be referred to henceforth as the "horseshoe".

The horseshoe can be divided into 3 segments a horizontal plane an anterior vertical, and a posterior vertical limb. At the points where the horizontal plane turns downward there are two curves, one anterior and the other posterior. At the site of the anterior curve there is an intermuscular hiatus which

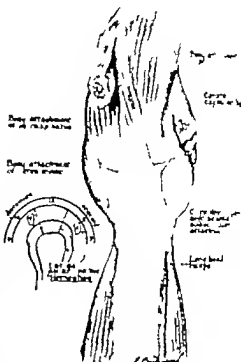


Fig. 6 Lateral view of the shoulder joint. Drawing made from anatomical specimen after removal of the clavicle and the acromion process of the spine of the scapula. Drawing illustrating outline of the greater tuberosity, the horseshoe with attachment of the supraspinatus conjoined tendon to the horizontal limb of the subscapularis to the anterior vertical limb, and the subscapularis teres minor muscle to the posterior vertical limb. The acromioclavicular joint, the coracoclavicular and the coracohumeral ligament. Diagram illustrating these points.

lies between the supraspinatus and the subscapularis capsular components.

In this opening, close to the anterior superior margin of the glenoid is the base of the coracoid process of the scapula. Sprung from this base is a heavy ligament. It spreads fanwise to blend with the capsule. Usually called the coracohumeral ligament, the term coracoclavicular would seem more descriptive. This structure grows in functional stature with study and will be discussed in the summary which follows (Fig. 7).

The infraspinatus teres minor are not only anatomically inseparable but can be considered as one muscle. They arise from pro-



Fig 7. Posterior view of the shoulder joint. Drawing from the same prepared specimen and diagram. Illustrating posterior view of the supraspinatus muscle and infraspinatus teres minor muscles. Insertion of infraspinatus teres minor conjoint tendon into the posterior limb of the "horseshoe" and the posterior capsular fold.



Fig 8. Anterior view of the shoulder joint. Drawing from the same specimen and diagram illustrating supraspinatus muscle and conjoint tendon with final insertion into the horizontal portion of the "horseshoe". Coracocapsular ligament. Subscapularis muscle attachment to the lesser tuberosity and to the anterior and posterior margins of the bicipital groove. Final insertion into the anterior vertical limb of the "horseshoe". Anterior capsular fold. Diagram illustrating these points.

tically the entire surface of the infraspinous fossa to fuse with the posterior portion of the capsule in a manner similar to that described for the supraspinatus. This conjoint tendon occupies the extreme posterior portion of the horizontal plane, the posterior curve, and the posterior vertical leg of the "horseshoe". The lowermost portion of this ends on the posterolateral surface of the surgical neck of the humerus. To this teres minor segment has been given the term the posterior capsular fold. It should be noted that the anterior separation is not duplicated posteriorly. In fact, beneath the recess of the acromion process, the muscle bodies of supraspinatus and infraspinatus are in intimate contact (Fig 8).

The subscapularis is a thick, powerful, fan-shaped muscle, originating from and almost covering the internal surface of the scapula, the subscapular fossa. The muscle fibers converge to become tendinous, just below the acromion process. At this same point the aponeurosis blends with the capsule of the

joint to become a conjoint tendon. The superior portion for a distance of about  $\frac{1}{2}$  inch is attached to the lesser tuberosity. The remaining portion of the tendon follows the anterior border of the bicipital groove. The lowermost portion ends far down on the surgical neck. This portion is referred to as the anterior capsular fold. The fibers then pass over the long head of the biceps and are again attached to the lateral margin of the bicipital groove to form the roof of the tunnel. There is then a short capsular expansion or prolongation which finds attachment to the anterior limb of the "U" previously mentioned. The fact that the bicipital groove is actually a part of the subscapularis tendon was clearly shown when the subscapularis muscle was excised *in toto*. The bicipital groove was clearly marked as an integral part of the under surface of the subscapularis tendon.

The anatomical description of the deltoid need not be given here. However it should be noted that the relationship of the deltoid to these capsular muscles follows a regular pattern that varies only with the subscapularis.

Embryological development frequently mirrors evolutionary changes. The deltoid, supraspinatus, and infraspinatus teres minor arise from a common premuscle mass. The subscapularis at first is separated from the other muscles and comes to occupy its final position somewhat later than the others (3).

To complete the anatomical picture the relation of these muscles as a group to the scapula should be mentioned. When the prepared specimen illustrating scapulohumeral head muscle attachments is viewed from below with the inferior angle of the scapula closest to the eye one is surprised by the thickness of the scapular muscle envelop. This is further demonstrated in a study of cross sectional anatomy and tends to confirm statements already made and those that follow as to the power of this group of muscles.

There is a general impression that these muscles are small. They are "short rotators" whose function it is to cause internal or external rotation, depending on the muscle in question. They have an added indefinite function depending on the textbook used of re-enforcing the capsule. The following simple experiment should dispel this fallacy.

From a large heavily muscled cadaver the following muscles were excised *in toto* and weighed. The deltoid, the subscapularis, the supraspinatus and the infraspinatus teres minor. At the same time the biceps, both long and short head was excised to furnish a basis for comparison. This was done for two reasons first because the biceps is a very familiar muscle and second, the long head has entered into procedures designed to stabilize the shoulder joint. The weights are as follows: the biceps, 121½ grams; deltoid, 391 grams; subscapularis, 191 grams; supraspinatus 65 grams; and the combined infraspinatus teres minor 61½ grams. It is recognized that these weights will vary with the size of the individual. When they are taken from the same individual however and compared with each other the proportional weights should

not vary greatly. The analysis of these figures is very interesting. It shows that the combined weight of these "short rotators" or capsular muscles was approximately 420 gram.

The combined weight of these muscles was greater than that of the deltoid. They are relatively more powerful than longer muscles in that they work in a very short arc. These findings would tend to show that they are not accessory muscles, but are of prime importance and are extremely powerful.

Summarizing, it would seem probable that these muscles stabilize the head in the glenoid by acting in combination and in abduction as a unit. A diagram (Fig. 9) was prepared to illustrate this point and was later found to closely resemble an anatomical cross-section made near the level of the head of the humerus. As is usually the case however diagrams tend to oversimplify a problem. The symmetrical anterior and posterior capsular folds would seem to have a specialized function. They should act most powerfully either together or singly depending on the anteroposterior relation of the elevated arm to the body.

The portion of the capsule lying between the subscapularis and supraspinatus has been called the coracohumeral or in this description, the coracocapsular ligament. It probably acts to prevent rotation in the first glenoid beyond a 90 degree arc. Movements beyond this point are performed by the entire shoulder girdle moving as a unit.

Before a description is given of the operative technique of reconstruction the alternative namely, resection without reconstruction, should be discussed. That alternative is the condition known as flail shoulder.

It is common knowledge that if the head of the humerus is removed to correct fracture dislocation, unreduced comminuted fractures or old unreduced dislocation or for other reasons a flail shoulder is the result. B.

Flail shoulder is meant one that is devoid of voluntary muscle control. There is a scarcity of references on this point as doctors with do not report their tragedies. One writer expressively described flail shoulder by saying the arm is merely a cumbersome appendage swinging laboriously from side to

side, which is from a practical standpoint, practically useless" (1) The head of the humerus is still being excised without further reconstruction Very recently an excellent orthopedist reported arthrodesing shoulders following complete transverse rupture of the "musculotendinous cuff" An arthrodesed shoulder is better than a "flail shoulder," but it is still far from being a good functional organ

In military surgery there are reports which would indicate that "flail shoulder" is an exceedingly common occurrence Nové-Josserand and Tuffier reported several large series of joint resections in 1916 In 1018 resections, there were 237 of the shoulder joint

The end-results were listed as follows stable shoulders with fair or limited mobility, 45 per cent, ankylosed, 11 per cent, and "flail shoulder," 38 per cent In another series of 98 cases, there were 45 per cent "flail shoulders" In free translation, they say that in these cases, function of the shoulder was completely lost, and as a direct result the forearm and hand became useless Their large series of cases, reported so early in the first World War and the frequency of the condition should combine to cause grave concern It is reasonable to expect that in the present war, current improvement in projectiles should increase rather than decrease the frequency of shattering fractures about the shoulder joint

The operative technique of the reconstruction of the shoulder joint will be given in considerable detail, as there have been many modifications since the preliminary report The operation has been used in carefully selected cases after repeated attempts had failed to secure satisfactory reduction It is the only satisfactory method known to the author, and time has shown that it is consistently effective Careful study of two splendid texts concerning orthopedic surgery lists neither this nor alternative procedures In all, 7 cases have been followed by this and other observers for periods varying from 3 to 16 years It is worth noting that, functional variation aside, seven consecutive cases finished with stable shoulder joints

Prior to the operation there are two points that should be noted A comfortable abduc-

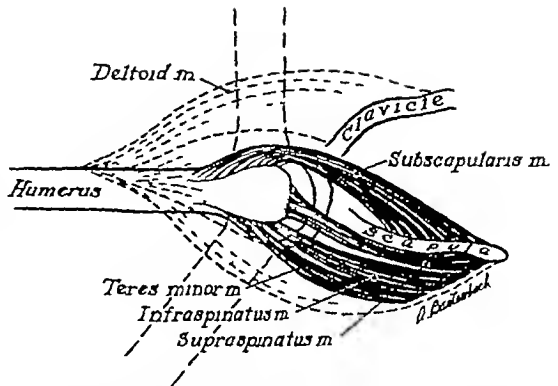


Fig 9 Diagram illustrating probable physiological action of the capsular muscle group in stabilizing the head of the humerus

tion splint adjusted to a 50 degree angle should be prepared The patient should be placed on his side and an assistant designated to hold the arm upon which the operation is to be performed Adequate posterior exposure requires this position, and during the course of the operative procedure, manipulation is essential

A six inch vertical incision is made on the anterior surface of the arm just below and lateral to the coracoid process (Fig 10a) It then turns laterally to skirt the acromioclavicular junction, and then passes posteriorly to just below the anterior portion of the spine of the scapula For further exposure, it may be extended below the spine The anterior deltoid fibers are separated, retracted, and the subdeltoid bursa is exposed For proper exposure, the deltoid must be incised following a line close to the acromioclavicular arch The capsule is opened by the primary "U" incision which follows the margin of the greater tuberosity It should be noted that this incision, when completed, mobilizes the head of the humerus and gives access to the glenoid

In the anatomical portion of this report, emphasis has been placed on the exact relation of the insertion of these muscles to the margin of the greater tuberosity or "horseshoe" This has been done to establish a foundation for certain necessary surgical landmarks At the operating table, instead of a prepared specimen, the surgeon is confronted by an intact acromioclavicular arch, and the smooth,

unbroken lower portion of the capsule. It has been shown that if one divides the "horse shoe" into horizontal anterior vertical, and posterior vertical limbs there is demarcation of the final point of insertion of the supraspinatus, the subscapularis, and the infraspinatus teres minor respectively. If in addition, a scale or clock is mentally superimposed on this intact bony arch, the muscle flaps are visualized (Fig. 10b). A short incision, starting at the anterior curve, is made toward the coracoid process or one o'clock, and another is made starting at the posterior curve toward the acromion or eleven o'clock. With this, two of the three conjoined tendons of the capsule are immediately separated into their respective parts and mobilized without further treatment. These are the supraspinatus and the infraspinatus teres minor. In comminuted fractures, in which the lesser tuberosity is usually fragmented, the upper portion of the subscapularis flap is likewise partially mobilized by the very existence of this fracture.

When it is not, or when varied surgical procedure requires the mobilization of a subscapularis flap it must be separated above by an osteotome from its bony attachment to the lesser tuberosity and below by sharp dissection from the bicipital groove.

The infraspinatus and the subscapularis flaps are completed by anterior and posterior transverse incisions made at the base of the "horse shoe." It has been considered advisable not to go beyond this base thus preserving intact, the anterior and posterior capsular folds (Fig. 10c).

The fractured head is removed (Fig. 10d). The conjoined tendon flaps are secured with clamps and drawn into the wound (Fig. 10e). Comminuted fragments which are still attached to them are separated at this time. The end of the shaft of the humerus is rounded and smoothed. On the lateral surface of the bone about  $1\frac{1}{2}$  to 2 inches from the rounded end two parallel grooves are made. These should be long enough to fit the prepared flaps. Another similar groove is made just above these and at right angles and drill holes are made at the ends of each groove. In short, the general configuration of the "horse shoe" is re-establish-

lished on the upper lateral surface of the shaft. Figure-of-eight silk sutures are now placed in the ends of each of these tendons (Fig. 10f).

The sutures and the tendons of the supraspinatus are placed in the upper groove, the subscapularis in the anterior vertical groove, and the conjoined tendons of the infraspinatus teres minor in the posterior vertical groove.

Then the silk ligatures are anchored, according to the desires of the operator. Suture of the margin of these tendons, the undersides of which are lined by serous membrane is what is necessary to re-establish the capsule of the shoulder joint. The arm is placed in 90 degrees abduction, and these tendons are adjusted to be taut without tension at this angle. The wound is closed in layers and the previously prepared abduction splint applied.

#### EVALUATION

In any group discussion of shoulder joint stability the question as to the relative importance of the long head of the biceps is quickly introduced. Cadaver experiments, which can be easily repeated, will demonstrate that section of the short rotators or capsular muscles as they fuse with the capsule completely disrupts glenohumeral head contact. These are the primary stabilizers. There are many secondary stabilizers and of these the most important would seem to be the muscles attached to the coracoid process, the short head of the biceps and the coracobrachialis.

One notes, everywhere the profound influence that the works of the late Dr. E. A. Codman have had on the medical thought on this subject. This is as it should be, but there has been too much emphasis on supraspinatus injury and the importance of the supraspinatus muscle. It has been shown to be the smallest of the three capsular components. It will continue to receive much attention, just as does the frail member of a set of triplets, the one that is frequently sick or injured.

This supraspinatus overestimate has led to the synergistic deltoid supraspinatus theory (Watson-Jones). This maintains that firm fixation of the humeral head in the glenoid by the supraspinatus is a prerequisite to deltoid function and followed the observation that abduction could not be initiated after a "re-

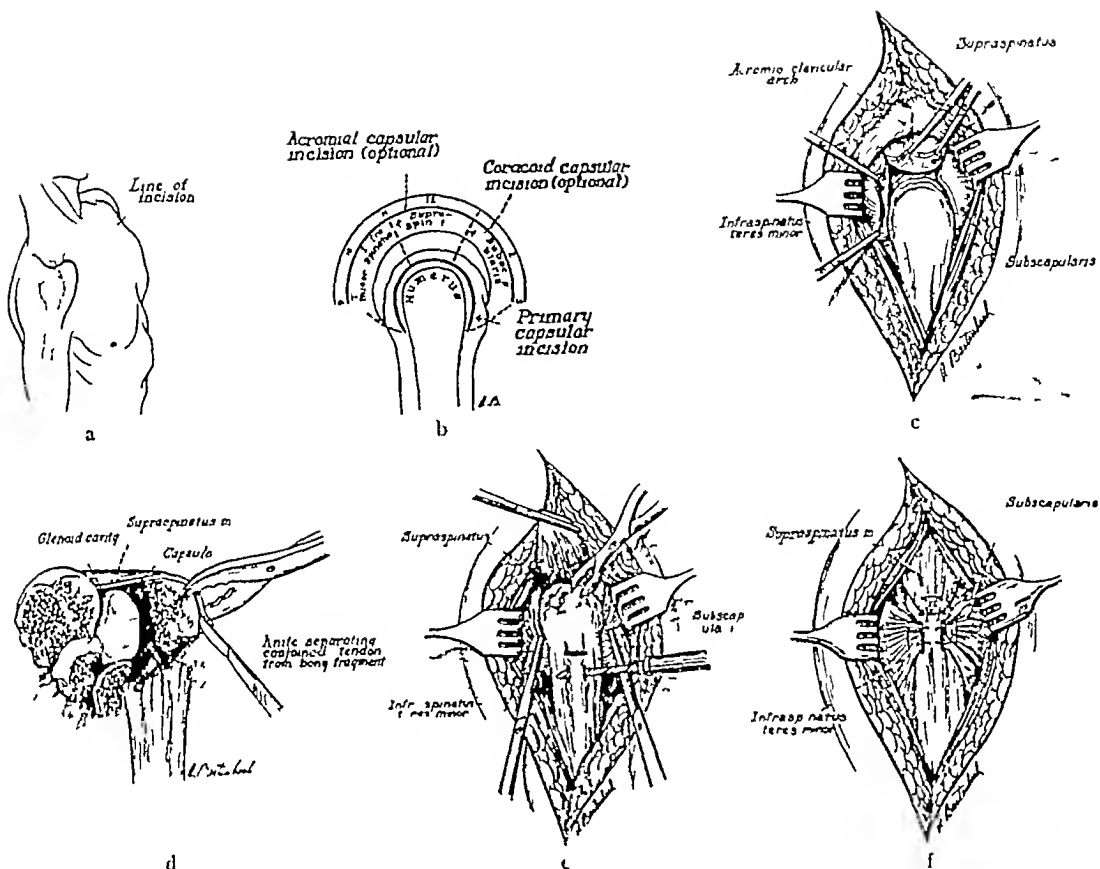


Fig 10 a Drawing showing the line of skin incision, b diagram illustrating the "horseshoe" and "shoulder lock" as an aid to localization of the component capsular flaps, c, drawing representing the aid of a diagram in the preparation of flaps, d, the removal of bony fragments from the conjoint tendon, e, the rounding of the upper

end of the shaft and preparation of three grooves, one horizontal and two vertical, prior to final transplantation of capsular components, f, final location of transplanted capsular tendons. Note that the line of closure between the components, such as the supraspinatus and infraspinatus, reconstitutes capsule

plete tear" of the supraspinatus. Study of the lateral aspect of the shoulder would show that any sizable laceration of the key-stone supraspinatus tendon would seriously affect the two components in front and back. Moreover, it would seem to be physically impossible for the supraspinatus alone to be a worthy antagonist for the deltoid which is six times larger and heavier.

Closer to the truth, yet still inadequate, was the statement made in 1933 (2), that the "short rotators" are in reality "suspensory muscles whose chief action it is to hold the head of the humerus firmly against the glenoid where the more powerful flexors and extensors can exert their full force on a firm base."

If this is not the whole truth, let us attempt to define our present concepts regarding the physiology of shoulder motion. *Movement of the shoulder demands both fixation of the glenoid and the head of the humerus, with effort increasing the demand. Two distinct muscle systems are involved in effecting this. Dysfunction of any muscle component will seriously disturb the fine muscle balance essential to normal shoulder movement.*

Finally, surgeons interested in the problems of bone and joint surgery will concur with the statement that occasionally resection of the head of the humerus is inevitable. Considering the operation as a surgical entity, they will agree that stabilization of such a

shoulder presents a difficult surgical problem. If such a shoulder can not only be stabilized, but reconstructed to effect functional return then other more or less distantly related problems in shoulder surgery should be affected.

#### SUMMARY AND CONCLUSIONS

1. Resection of the head of the humerus is reported in two illustrative cases.

2. In these and other individuals the end-result has been stable shoulders but with considerable variation in function.

3. Investigations to determine the reason for this have considerably altered our ideas concerning the basic anatomy and physiology of the shoulder. (a) Normal shoulder movement demands both fixation of the glenoid and the head of the humerus. (b) there would seem to be a considerable difference in the muscle physiology of the shoulder joint in relaxed motion and when the same joint performs

under the stimulus of effort. (c) the analogous results can be summarized by saying that the "short rotators" are in reality complex muscles, and that these are divided into three distinct component parts.

4. An operative procedure is described for in selected cases has been consistently effective. It has simplified surgical approach and when modified can meet varied surgical needs in civilian practice.

5. Reports from the first World War led to the belief that in military surgery a reconstructive operation of the type described would be of great service.

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# THE SURGICAL EXPOSURE OF THE GALL BLADDER AND BILE DUCTS

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TO those who for many years have been operating upon patients with gall stones, a discussion of the surgical exposure of the gall bladder and bile ducts must seem almost presumptuous. I would not consider presenting the matter were it not for the fact that, in my opinion, there is a real need for improving the methods now in general use. The exposure obtained by the procedures which I developed some years ago has been so satisfactory in our clinic and has received such favorable comment from others visiting the clinic that I feel it timely to describe the steps used. I am convinced that this plan will often make possible better operative procedures not alone upon the bile ducts but as well upon the very important area at the junction of the cystic, common and hepatic ducts, and a wide area adjacent, in addition, and of great importance, the operation can be carried out under direct vision.

No one who has done very much biliary tract surgery will deny that the area most dangerous, most involved, and most likely to produce complications in biliary tract surgery, lies at the very bottom of what in the operative field may be described as a very deep hole. The very bottom of this deep hole is made up of the bile ducts, the often complicated and atypical anatomical relationships between the cystic duct, the common duct, the hepatic duct, and accessory ducts, the cystic artery, the hepatic artery, at times the portal vein, the duodenum, and the head of the pancreas. Excessive bleeding from tearing of the cystic or right branch of the hepatic artery in this deep hole, unless there is adequate exposure, creates an emergency which threatens life, inaccurate control of hemorrhage can and does cause injuries to the bile ducts which result in almost irreparable strictures.

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For 16 years I have presented my views concerning the need of taking certain steps in operating for gall stones that are located in the gall bladder and in the bile ducts, that those within the bile ducts are removed. This can be done by the use of the bile ducts, exploration will reveal the presence of stones in approximately half of the cases. The ability of a group of several surgeons at this clinic to open and explore the biliary tract and yet show an ever decreasing mortality rate is I believe, in a large measure due to their use of this method of exposure. In the operative field, an exposure which enables the surgeon to operate upon the ducts and adjacent structures through a wide anatomical exposure in a dry field, with adequate light, and without patient's abdominal muscles and contents relaxed and quiet.

I believe that any method of exposing the biliary tract region should be developed in sequential lines. The basic factor of such a method is, in my opinion and experience, a quiet, relaxed abdominal wall and contents. This can be obtained with proper spinal anesthesia, without which the plan of exposure here described becomes, if not impossible, at least very much less satisfactory.

To silence possible criticism of the plan, since its most completely satisfactory employment requires spinal anesthesia, I would like to say that for several years in this clinic all abdominal operations have been done under spinal anesthesia—gas anesthesia or intravenous pentothal anesthesia being used when desired to protect the patient from the psychic burden of being awake while the operation progresses. The spinal anesthesia has always been given by a full time, trained physician anesthetist from the department of anesthesia in the clinic. As evidence of the safety of the method there have been no deaths from this type of anesthesia for years.



and there has been to date not a single neurological complication. It seems obvious to me, therefore from an experience of approximately 15,000 cases, that in the hands of those trained so as to be expert in its administration and maintenance spinal anesthesia has been proved to be a safe and most satisfactory type of anesthesia. In the hands of those not trained and experienced as experts in this type of anesthesia, I would be the first to admit its hazards—the employment of spinal anesthesia by those unqualified in its use by training or experience has brought about untoward criticism and has created unjustified prejudices against it. As in so many parallel situations in scientific practice just as it provides such beautifully quiet and relaxed anatomical fields for delicate, accurate and meticulous dissections, so it also demands care, patience, and experience not only and most important, in its administration but also in meeting the emergencies which sometimes arise during its administration. Such emergencies can be successfully dealt with by those expert and experienced in its management.

The number of reports of attempts to make the main bile ducts more visible and so more easily approached is evidence that surgeons realize that adequate exposure of the operative field in biliary tract surgery is essential if such operations are to be conducted safely. The attempts to improve the exposure of the ducts have been largely concerned with placing objects under the patient's back at the level of the gall bladder and bile ducts. At first sand bags were used, then mechanical back elevators with the patient in the reversed Trendelenburg position were employed the idea being to remove from the field of gravity the adjacent anatomical structures. Early in our experience we adapted for the purpose a section of balloon tire inner tube. The section chosen included the valve for inflation. Pieces of rubber were vulcanized over the cut ends of the tube. The section of tube uninflated, was placed beneath the patient's back. It

was connected with an air bottle or gas unit and later inflated when the patient's abdomen was opened and the gall bladder exposed. All of these procedures were based upon fallacious reasoning that thus removing the adjacent anatomical structures from the field would make the ducts more accessible. The methods were not productive of very much improvement in the exposure of the ducts and the cystic and common duct junction. The fact that the common and hepatic ducts, together with the cystic junction and associated area are lax structures makes difficult the exposure of the area—hence it is difficult to bring the structures close to the abdominal wall when they can be dealt with more safely. The structure into which the ducts enter—the duodenum—because of its mobility tends to move to the right toward the point of origin of the ducts and is fixed in the fissure of the liver and so permits the ducts to sink back into the very bottom of the operative field, which has been called the pouch of Morson. Nothing placed under the back will overcome the laxity of the duct or sufficiently elevate the posterior abdominal wall so that the bile ducts will be made more visible and brought nearer to the surface so they can be more safely dealt with.

It was realized that only by mobilizing to the left the structure into which the duct was inserted and keeping its origin in the fissure of the liver fixed, could the duct be straightened out, put on the stretch, and thus brought up out of its deep position and made clearly visible and closer to the abdominal wall.

The length of the incision is also an important factor in the exposure. Comparison of what one gains or hazards with incisions of adequate or inadequate length reveals a great deal. With any incision that limits ease and adequacy of exposure of the deep anatomical structures of and about the bile ducts, one exchanges the saving of 3 or 4 inches of the incision in the abdominal wall for whatever the additional risks are to the deep anatomical structures, and because of this the patient's future.

#### THE TECHNIQUE

Spinal anesthesia is used and an incision of ample length is made. The abdomen is then

Some years ago there was established at the Laker Clinic, a school to train anesthetists, both provided, both some years of general training in the subject. From this school, anesthetists trained in all branches of anesthesiology have been placed yearly in positions as different as those of the anesthesiologist, being given by other groups and by individual anesthetists throughout the country, so that increasing numbers of very capable and safely administering spinal and every type of anesthetic are being made available.

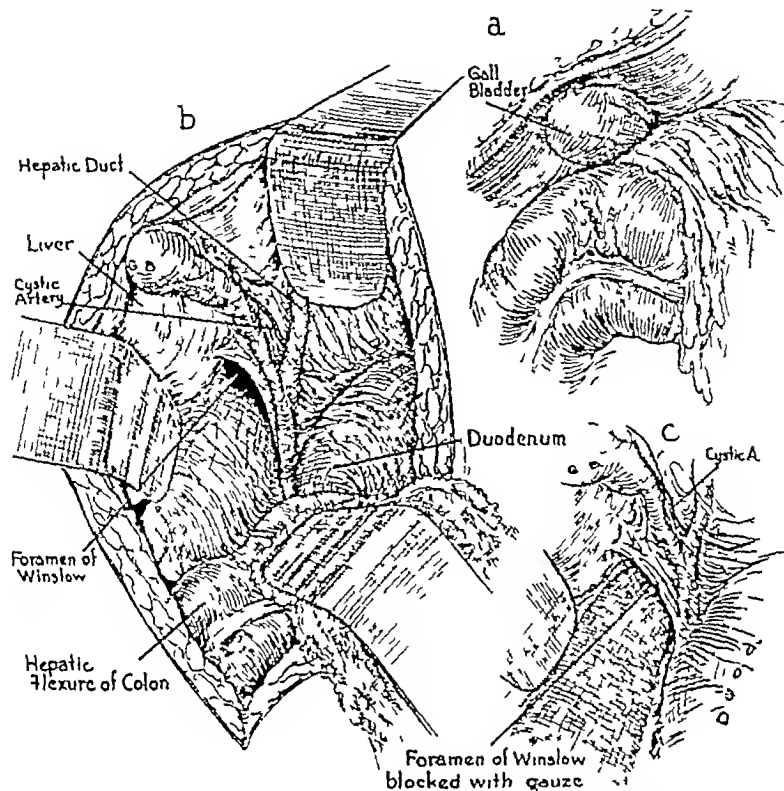


Fig 1 a, The anatomical relations of the gall bladder and hepatic flexure when the abdomen is first opened b, The hepatic flexure and duodenum mobilized to the left and held in this position with retractors upon gauze pads The clamp on the gall bladder is not shown, but by traction and mobilization of the duodenum and hepatic flexure to the left this exposure of the ducts and foramen of Winslow is obtained Note also the visualization of the cystic artery with the peritoneum over the duct opening c, The foramen of Winslow blocked with gauze

opened and the gall bladder is exposed and grasped with a right angle clamp or any other type one prefers The gall bladder is pulled upward and outward and the duodenum is pulled to the left so that any bands between the duodenum and the gall bladder are put on the stretch and severed The hepatic flexure, which is often fixed by bands to the under surface of the liver, is freed so that the flexure can be completely dislocated to the left The field is then ready for exposure A long, folded, wet pad is placed over the outer edge of the duodenum up to the pylorus and with a Deaver type of retractor placed over it retraction is made to the left The hepatic flexure and ascending colon are pushed over to the left and another gauze pad is placed along their external edges (Fig 1, b) A

Deaver type of retractor is placed over this area and the flexure and ascending colon are pulled to the left This procedure, the retractor pulling the wound edges apart, completely exposes the pouch of Morison The common and hepatic ducts are put on the stretch as these two structures—the duodenum and hepatic flexure with the retrocolic duodenum behind it—are pulled to the left so that the ducts are made completely visible If another clamp is now placed upon the ampulla of the gall bladder and the gall bladder is further elevated, traction on the cystic duct will not only demonstrate the duct and its entrance into the common duct plainly but will so open the foramen of Winslow that it, with its posterior boundary made by the vena cava, will be plainly visible (Fig 1 b)

With an exposure such as this, a gauze strip can be passed into the foramen of Winslow to block it (Fig 1 c). The remainder of the strip may be so laid into the fossa of Morison that, as one will quickly see when this exposure is obtained, should a considerable amount of infected bile escape in opening the ducts or should a pool of blood accumulate at the very apex of the deepest point of the operative field represented by the foramen of Winslow material thus released will not pass into the lesser peritoneal cavity or pool at this point to produce a subhepatic or subphrenic postoperative abscess. For several years I have advocated among our group of surgeons the value of plugging the foramen of Winslow and packing the fossa of Morison, and I am sure this precaution has rewarded us in better results, in that catching the spilled bile and stones has prevented complications.

With this exposure, flaps of peritoneum can be safely cut from the gall bladder with which to cover its bed after its removal. The course and position of the hepatic artery and the course and relation of the cystic artery to the cystic duct can be readily demonstrated and visualized (Fig 1 b and c). Accurate dissection of the cystic duct down to the point of entrance into the common duct can be accomplished. Not infrequently the discharge of bile from torn, small accessory ducts occurring at this point can be demonstrated the open end of the accessory duct picked up and tied and the postoperative escape of bile into the wound from the open end of the accessory duct prevented. As the result of having again

and again demonstrated after removal of the gall bladder, torn accessory bile ducts either at the junction of the cystic and the common and hepatic ducts, or in the bed of the liver I am sure that when there is an escape of bile after cholecystectomy it is in most cases from tears not discovered and therefore not ligated in the accessory bile ducts. That the escape of bile particularly from an accessory bile duct in the bed of the liver can result in the escape of a serious amount of bile into the peritoneal cavity is borne out by one case I have encountered. In this instance a torn duct in the liver bed leaked at least a dram of bile per minute and undoubtedly within a few days would have completely filled the abdomen with bile. While it is true that bile peritonitis can frequently be recognized and controlled it is a complication to be prevented and can be avoided if proper precautions are taken.

By this exposure the cystic artery as we have frequently demonstrated, can always be found first carefully dissected, cut, and clamped, and then the dissection between the cystic, common and hepatic ducts can be made very accurately. I believe nothing has played a greater part in lowering our mortality rates or has given us the confidence to explore the common ducts in such a high percentage of cases as has this plan of exposure. After its use for a number of years we can say without hesitation that the traction made upon the duodenum and the hepatic flexure by retractors on the top of gauze in no way increases the postoperative distention or complicates the postoperative recovery.

# SURGICAL REPAIR OF RECENT LID LACERATIONS

## Intramarginal Splinting Suture

HENRY MINSKY, M D, New York New York

LACERATIONS of the eyelids, while not uncommon in civil practice, are seen very frequently as part of war injuries. The ophthalmologist knows the importance of immediate precise repair, but others who see these cases first are less likely to be aware of this necessity.

When injuries involving the margin of the lid are not perfectly repaired, faulty healing due to the change in the action of the strong band of orbicularis muscle fibers near the cilia causes cosmetic defects and functional disturbances.

This disturbed physiology was markedly demonstrated in 1 of the 25 cases that form the basis for this communication. During a brawl, a man had his right upper lid torn 5 millimeters from the punctum by a laceration which extended 7 millimeters upward and then ran parallel to the margin up to the external lateral ligament. When the patient closed his eyes forcibly, the tip of the flap rose away from the eyeball and stood erect. When he opened his eyes, the orbicularis became relaxed and the flap came to rest flat against the eyeball. At the time of injury, a reflex spasm of the orbicularis takes place which accounts for the displacement of the tongue toward one canthus or the other. The almost constant beveling of the wound is thus also explained. Once the margin is torn, the action of the orbicularis is changed to a lateral traction which tends to separate the lips of the wound and ultimately to cause a notch.

The methods of repairing lid lacerations deal mainly with three problems: (1) the perfect apposition of the margins of the lid border to prevent the formation of a notch, (2) increasing the raw area in the substance of the lid itself to create a broader adhesion, (3) the overcorrection of an avulsed lid to insure its approximation and to restore its level.

### LITERATURE

The procedures used prior to the World War in the repair of fresh lacerations of the lid

From the Ophthalmological Service of Harlem Hospital. Presented before New York Academy of Medicine. Section of Ophthalmology. February 19, 1940.

margin are merely suggested in the literature dealing with ectropion, tumors, congenital colobomas, and the post-traumatic notch. Duverger (2) in 1916, described the removal of a triangle of skin and orbicularis from one side of the wound, and a similar equal triangle of tarsus and conjunctiva from the other, thus permitting the tissue to overlap to produce a "Z" shaped base of adhesions when the lid was finally repaired. Attention was focused on placing the deep sutures off to one side of, and not directly behind, the superficial skin sutures. It is interesting in this connection to note that when Sheehan, 10 years later, pictured Duverger's operation, he added two tiny intramarginal sutures, which he termed "the most important suture."

In 1920, Wheeler (16) published a description of his "Halving Operation" in which he perfected Duverger's overlapping technique. In one patient in whom the globe had been previously lost, he "sewed the lids together so that the lower margin would act as a splint for the upper." To Wheeler then, belongs the credit of splinting one lid margin against the other. He laid particular stress on the importance of a flamed-adhesive pressure dressing reinforced with a supporting bandage. This pressure dressing insures primary union by immobilizing the tissues, and prevents infection or at least minimizes it by forcing the exuded serum into the dressing.

Still later, Peter, 1932, suggested the suturing together of both lids when the injury was extensive, and even recommended intramarginal tarsorrhaphy.

### CLASSIFICATION

Recent lid lacerations may be classified as follows:

A. Extramarginal, not involving the lid border. They may be (1) superficial or (2) deep.

**B Intramarginal** Intramarginal lacerations may be (1) canalicular (avulsion) or (2) extracanalicular. Extracanalicular lesions may affect (a) one lid and be either single or multiple or (b) they may affect both lids and consist of (1) one tear in the margin of one lid at a point distant from the tear in the other or have (2) both tears in a line and continue through the margin of both lids.

### TREATMENT

The general principles of treatment universally accepted have been repeatedly stressed in the literature by various authors. They may be summarized briefly as follows:

Prompt repair gives the best results because it avoids later deformities. Simple suturing of the edges of a defect is adequate if less than one third the length of the lid is missing. Proper cleansing is mandatory. Debridement should be minimal though definitely necrotic tissue must be excised.

Braided and ecchymotic tags of tissue may be saved.

The use of intramarginal suture is essential.

Closing of conjunctiva to prevent adhesions to the globe is required.

Suturing of levator and tarso-orbital fascia is necessary to avoid ptosis.

Repairing the orbicularis should not be neglected. A special suture near the cilia should be made to catch the muscle of Roulon to prevent the formation of notch.

Precise suturing of skin restores the continuity of the lid.

Both eyes should be bandaged to maintain immobilization of the sutured lid.

Wiener suggested trimming the lips to optical defect so as to avoid notch.

**Anesthesia** In the great majority of cases instillation in the conjunctiva of 4 per cent cocaine and adrenalin and a tampon of 1 per cent pontocaine in the lower sac plus the infiltration of the lids with 2 per cent or 4 per cent novocain render the repair painless. Only when the patient is nonco-operative is general anesthesia indicated.

**Dressing and after-care** The moderately severe compression dressing is not disturbed for 5 days. Then, all superficial sutures are removed while the patient is asked to keep both eyes shut. A light dressing is applied. On the following day the eye is left open but the wound is kept covered with 2 per cent boric acid ointment for a week.

### EXTRAMARGINAL LACERATIONS

Superficial wounds of the skin require simple cleansing and coaptation either by interrupted sutures or by butterfly adhesive strips. A light dressing is sufficient.

Deep lacerations require thorough cleansing with soap and water, alcohol and ether and painting with iodine. The conjunctiva and the expansion of the levator aponeurosis are together closed with interrupted silk suture. Then the skin and orbicularis are similarly treated. A moderately heavy pressure dressing usually eliminates the necessity for drainage of the wound, even when contaminated, and almost always insures primary healing.

### SPECIALLY DEvised SINGLE INTRAMARGINAL SPLITTING SUTURE

When only one lid margin is lacerated, a strong double armed suture is passed through the tips of the wound by equal quadrant arcs in the plane of the gray line. As the lid is drawn away from the eyeball by this suture, the previously adjacent edges of the lacerated conjunctiva, levator expansion, and tarsus are approximated so that they may be repaired by buried interrupted catgut sutures. When the arms of this intramarginal suture are then brought through the gray line of the intact margin of the other lid to emerge from the skin beyond the cilia, the ends are led over a rubber bolster. In this way a splitting mechanism of the torn border is created. Since the lines of traction are all in the plane common to the gray line of each lid, any anterior-posterior displacement is avoided and since the intact border of one lid flattens the torn margin of the other, no vertical displacement can take place. The varying degree of beveling of the wound usually present serves to increase the surface for adhesion.

### DETAILED STEPS IN THE TECHNIQUE

4. **Intramarginal suture placed** A No. 1 braided silk double armed suture is used. The temporal flap is grasped with fixation forceps, nearly parallel to the border. The point of the needle is placed on the gray line 3 millimeters from the torn edge. It is passed in the plane of the gray line to appear in the raw surface 3 millimeters from the border (Fig. 1). The

# MINSKY SURGICAL REPAIR OF RECENT LID LACERATIONS

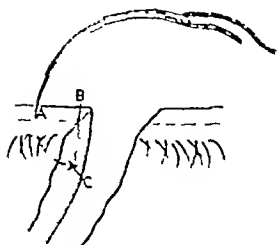


Fig 1

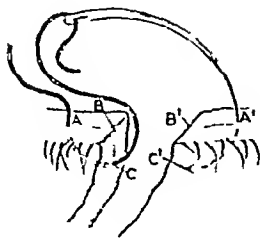


Fig 2

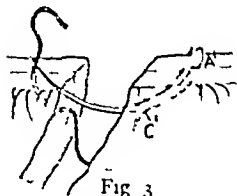


Fig 3

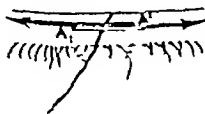


Fig 4

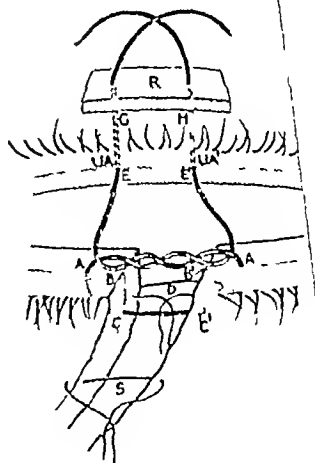


Fig 5

Fig 1 First step of intramarginal suture The lacerated lower right lid is schematically represented The front horizontal lines suggest the gray line where the needle is poised at 4 and the broken arrows indicate the path of the needle point through the thickness of the lid in the plane of the gray line AC The lowermost small arrow at C is the site of exit in the torn surface  $AB=BC$

Fig 2 Second step of intramarginal suture tract made in other lip The temporal arc of the suture has been drawn through and the tract 1 C' in the nasal lip is begun  $AB=B'C'$  and  $1C=1'C'$  Needle is not drawn through

Fig 3 Third step of intramarginal suture After the tract A C' is made, the needle is withdrawn and grasped by the needle holder nearer the point and the eye of the needle entered in the hidden raw surface at C to emerge at 1

Fig 4 Crossing of the suture on the gray line to check alignment of the flaps The arrows indicate the direction

that the arms of the suture are drawn so as to approp the torn flaps If vertical or horizontal displacement present, the arcs 1C and A'C' in Figure 3 are unequal the second (nasal) tract must be reformed

Fig 5 The intramarginal suture completed D represents one of the conjunctival sutures whose loops are buried between the raw surfaces when the skin is repaired The first half of a surgeon's knot (A-A') has been formed but not pulled tight The nasal arm of the suture emerges from A' now lies over 1 and has been made to enter gray line of the upper lid at L  $FE'=AB+1'B'$  travels in the plane of the gray line FG to emerge from skin at G 4 millimeters above the border The other arm follows a similar path R shows the rubber bolster on which the suture is tied after the stick has been taken S indicates one of the interrupted skin sutures

nasal flap is then grasped and the suture is entered in the torn edge 3 millimeters from the tip in such a way that it travels in the plane of the gray line where it appears exactly 3 millimeters from the tip of the nasal flap

To make certain that the second arc is in the plane of the gray line the following variation in the technique is used

The fixation forceps are released, applied to the nasal flap 5 millimeters from its torn edge The same needle used in making the temporal arc in the tip is placed on the gray line 3 millimeters from the nasal torn edge and made to produce a tract in the plane of the gray line which emerges in the raw wound 3 millimeters below the border (Fig 2) Without releasing the needle from the holder, the surgeon with draws it and re enters the tract at the previous point of exit of the needle Its point is made to emerge from the gray line where it was first punctured Another variation may be used by letting the threaded eye of the needle enter the tract at its opening in the wound and retrace its path much as a small curved probe would do (Fig 3) The needle holder

now grasps the needle near the eye, pulls it through the tract, thus drawing the suture and completing the first loop of the intramarginal suture

**B Alignment checked** To insure the exact alignment of the two flaps, the arms of the suture are crossed without being tied so as to lie on the gray line of the lid border (Fig 4) If there is any displacement, vertical or forward, it must be assumed that one part of the loop is outside the plane of the gray line The corresponding arm of the suture must be withdrawn and repassed accurately

**C Conjunctiva-tarsus repaired** The lid is everted by drawing it away from the eyeball by means of the still untied intramarginal suture Because of the traction by this loop, the margins of the conjunctival wound fall in line so that previously corresponding parts are now adjacent and easily recognized After the wound is permitted to spread a bit, inter-

rupted No. 000 plain catgut atraumatic sutures, starting at the angle of the tear and approaching the border are passed so that the loops (Fig. 5 D) are on the conjunctival side and the knots are tied so as to be buried between the raw edges when the skin is ultimately repaired. Catgut is used to make unnecessary the later removal of deep sutures, thus avoiding the risk of stretching the lid and of weakening the adhesions. If the repair of the conjunctiva is omitted the fornix in the region of the tear may be obliterated by scar tissue when healing is complete.

**D. Splinting procedure.** To obtain smooth union of the lacerated lid margin it must be splinted against the opposite intact one by tying the first half of a surgeon's knot which draws both tips of the laceration together.

Two turns are made in the first half of the surgeon's knot. The second part of the tie is here omitted. When drawn snug, with the arms of the suture held vertically, the half-tie prevents slipping of the knot and thus holds the wound closed. At this point the upper lid is grasped by fixation forceps at point corresponding to the tear in the lower border and the needle (the only one that has been used up to now) coming from the nasal flap of the lower lid, but now lying crossed on the lid margin, is slide over the temporal lip of the wound, enters the plane of the gray line of the upper lid perpendicularly just temporal to the fixation forceps to emerge in the skin 4 millimeters above the cilia (Fig. 5). The other needle enters just nasal to the fixation forceps in a similar manner. An interval of 6 millimeters separates the two arms.

The sutures (now crossed) are passed in the plane of the gray line of the other intact lid to appear in the skin 4 millimeters above the cilia where they are tied over a rubber bolster.

A rubber bolster previously cut from catheter tubing is held in a artery clamp (right angles to the tube long axis, and the needles re-passed from the concave surface of the catheter through it close to the artery clamp. This bolster is now pushed along the arms of the suture down to the skin, and the artery clamp released. The slack of the suture is taken up and the first part of a square knot made on the bolster. This taking up of the slack is repeated till the lips of the wound are just snug enough to be sure that the sutures shall not cut through later when the tissues become edematous. Finally the square knot is completed.

**E. Repair of skin and orbicularis.** Interrupted No. 1 twisted paraffined black silk su-

tures, starting from the angle of the wound and approaching the lid margin, close the skin and orbicularis. It is most important to make sure that a separate stitch is taken to hold the strip of orbicularis near the lashes, on the Riolan's muscle.

**F. Dressing.** A thin layer of sterile vaseline is applied to the lids and an adequate amount of gauze stuffs is pressed down with moderate pressure by stretched, flamed adhesive strips as Wheeler recommended in his grafting operations on the lids. Five days later all the sutures are removed, the patient having first been cautioned to keep both eyes closed without squeezing while this is being done. In 7 days the eyes are left open. The wound is kept covered with 2 per cent boric ointment for an additional 2 weeks.

#### DOUBLE INTRAMARGINAL SPLITTING SUTURE

If both lids are injured by laceration at different points on the borders, two double armed intramarginal splitting sutures are necessary. Each is placed as here described, the first half tied after the conjunctival repair and finally brought through the opposing intact portion of the other lid and carried through a rubber bolster. Only after both bolsters in place is the first suture tied; otherwise it would be difficult to insure accurate approximation of the second splitting suture. At the end of this procedure the torn lower margin will be held firmly against the intact upper, and vice versa.

#### FIGURE-OF-EIGHT SPLITTING SUTURE (FIG. 6)

When the lacerations of both lids meet at a point so that there is no opposing intact portion of lid to be used as a splint, the four tips of the borders are brought together by one double armed suture in the plane of the gray lines passed so as to form a figure-of-eight. When tied over a bolster the four tips meet in a point splinting one against the other and the suture restores the continuity of the margins of the lids.

The technique may be outlined as follows (Fig. 6): 1. Lower intramarginal suture is placed as above. (2) temporal arm. (3) nasal tract. (4) (5) the nasal arc threaded and (4) also cement is checked.

*B* The suture is crossed on the lid margin,  $AE'$  and  $A'E$ , but no part of a knot is made. The loop in the lower lid now forms the lower half,  $\backslash ACC' /$  of the "figure-of eight"

*C* Lower conjunctiva repaired

*D* The upper intramarginal loop. Temporary intra-marginal suture placed in the lid and then removed to make place for the loop after upper conjunctiva has been repaired

1 Temporal arc,  $EO$ , is entered by the needle which comes from  $A'$  the nasal lip of the lower lid margin, emerging from the raw surface of the temporal side of the upper laceration 3 millimeters above the border,  $O$

2 Nasal arc,  $EO'$  is entered by the needle which comes from  $A$  the temporal lip of the lower lid margin emerging from the raw surface of the nasal side of upper laceration 3 millimeters above border,  $O'$

3 At this stage the suture lies in the depth of the wound, the arms crossing a second time forming in the upper lid the top of the figure-of-eight,  $\backslash EOO'E' /$ . Each suture is now continued in the plane of the gray line, into the opposite edge,  $D$  and  $D'$ , 2 millimeters above  $O$  and  $O'$  and emerges from the skin 3 millimeters from the torn edge,  $S$  and  $S'$

*E* The suture tied over a rubber bolster, after the slack is taken up, splints the four tips against each other

*F* Skin and orbicularis repaired by interrupted silk sutures

#### AVULSION OF THE LOWER LID (FIGS 7 to 9)

In any consideration of the repair of avulsion of the lower lid, Wheeler's ideas contribute the major portion of the discussion. He (17) first showed how there is "a strong tendency for the flap that has been torn loose to heal in a position too low and not close enough to the eyeball so that an ectropion results, with inability to close the lids properly. In adjusting such a wound it is important that the angle of the flap be carried upward and backward to a point of overcorrection. To accomplish this, after suturing the conjunctiva with fine silk sutures, introduce heavier silk sutures (No. 5) through the skin in a diagonal direction, and apply a gauze dressing with pressure bandage"

The following excerpts from Wheeler's *Collected Papers* are of interest

"Proper anchorage of the angle of the lid flaps backward and upward in a position of slight overcorrection is important. This can be accomplished by carrying the skin sutures through more deeply in the tissues on the nasal side than in the lid flap, and by anchoring the apex back to the canthal ligament, carry the angle of the flap as high as possible" (p. 113)

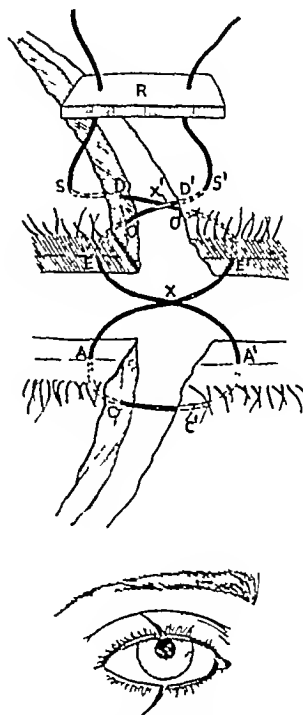


Fig. 6 The figure-of-eight suture. When both lids are lacerated at a common point. The arcs  $AC$ ,  $A'C'$ , and  $EO$ ,  $E'O'$  are all equal.  $A$ ,  $A'$ ,  $E$ , and  $E'$  are on the gray line, and equal distance from the tip.  $C$ ,  $C'$ ,  $O$ , and  $O'$  are on the raw edge in the plane of the gray line a similar distance from the tip.  $D$  and  $D'$  are on the raw surface in the plane of the gray line and  $DO = D'O'$ . The first crossing  $X$  lies between the lid margins in the plane of the gray lines. The second crossing  $X'$  is in the plane of the gray line between the raw edges of the upper wound. The sutures emerge 3 millimeters from the edge at  $S$  and at  $S'$  and are finally brought through the rubber bolster  $R$ . On taking up the slack of the suture all four tips of the lacerations are accurately approximated and splinted one against another.

"The margin of the lid flap is apt to be too narrow. It is important that the opposing raw surfaces should match. A simple and effective scheme is to split the lid flap at its edge and then increase its healing surface so that it will cover the opposing healing surface. The conjunctiva should be carefully sutured before the skin sutures are placed in the end of the flap" (p. 114)

"Some little nasal flap of skin can be seen and the tarsal flap slipped up and behind the little skin flap and held there by a mattress suture, tied so as to assure apposition of the raw surface, but not too tightly. Then the end of the tarsus was anchored upward and backward securely by a suture which passed through the canthal ligament. It is safe to tie such a suture snugly. In the healing process there was no slipping of the flaps. One can afford to



rupted No. 000 plain catgut atraumatic sutures, starting at the angle of the tear and approaching the border are passed so that the loops (Fig. 5, D) are on the conjunctival side and the knots are tied so as to be buried between the raw edges when the skin is ultimately repaired. Catgut is used to make unnecessary the later removal of deep sutures, thus avoiding the risk of stretching the lid and of weakening the adhesions. If the repair of the conjunctiva is omitted, the fornix in the region of the tear may be obliterated by scar tissue when healing is complete.

**D. Splinting procedure.** To obtain smooth union of the lacerated lid margin it must be splinted against the opposite intact one by tying the first half of a surgeon's knot which draws both tips of the laceration together.

Two sutures are made in the first half of the surgeon's knot. The second part of the tie is here omitted. When drawn snug, with the arms of the suture held vertically, the half tie prevents slipping of the knot and thus holds the wound closed. At this point the upper lid is grasped by fixation forceps at point corresponding to the tear in the lower border and the needle (the only one that has been used up to now) coming from the nasal flap of the lower lid, but now lying crossed on the lid margin, is slide over the temporal lip of the wound, enters the plane of the gray line of the upper lid perpendicularly just temporal to the fixation forceps, and emerges in the skin 4 millimeters above the cilia (Fig. 5). The other needle enters just nasal to the fixation forceps in similar manner. An interval of 6 millimeters separates the two arms.

The sutures (now crossed) are passed in the plane of the gray line of the other intact lid to appear in the skin 4 millimeters above the cilia where they are tied over a rubber bolster.

A rubber bolster previously cut from a catheter tube held in an artery clamp at right angles to the tie as long axis, and the needles are passed from the concave surface of the catheter through it, close to the artery clamp. This bolster is now pushed along the arms of the suture down to the skin, and the artery clamp released. The slack of the suture is taken up and the first part of a square knot made on the bolster. This taking up of the slack is repeated until the lips of the wound are just snug enough to be sure that the sutures shall not cut through later when the tissues become edematous. Finally the square knot is completed.

**E. Repair of skin and orbicularis.** Interrupted No. 1 twisted paraffined black silk su-

tures, starting from the angle of the wound and approaching the lid margin, close the skin and orbicularis. It is most important to make sure that a separate stitch is taken to hold the strip of orbicularis near the lashes, and Riolan's muscle.

**F. Dressing.** A thin layer of sterile vaseline is applied to the lids and an adequate amount of gauze fluffs is pressed down with moderate severe pressure by stretched flamed adhesive strips as Wheeler recommended in his graft operations on the lids. Five days later all the sutures are removed, the patient having first been cautioned to keep both eyes closed without squeezing while this is being done. In 7 days the eyes are left open. The wound is kept covered with a 1 per cent boric ointment for an additional 2 weeks.

#### DOUBLE INTRAMARGINAL SPLINTING SUTURE

If both lids are injured by lacerations at different points on the borders, two double armed intramarginal splinting sutures are necessary. Each is placed as here described, then is half tied after the conjunctival repair and finally brought through the opposing intact portion of the other lid and carried through a rubber bolster. Only after both bolsters are in place is the first suture tied; otherwise it would be difficult to insure accurate approximation of the second splinting suture. At the end of this procedure, the torn lower margin will be held firmly against the intact upper and vice versa.

#### "FIGURE-OF-EIGHT" SPLINTING SUTURE (FIG. 6)

When the lacerations of both lids meet at a point so that there is no opposing intact portion of lid to be used as a splint, the four tips of the borders are brought together by one double armed suture in the plane of the gray lines passed so as to form a figure-of-eight. When tied over a bolster the four tips meet at a point splinting one against the other and the suture restores the continuity of the margins of the lids.

The technique may be outlined as follows (Fig. 6):

1. Lower intramarginal suture is placed as above. (1) temporal arc, (2) C, (3) nasal tract, (4) C, (5) the nasal arc threaded, and (6) alignment is checked.

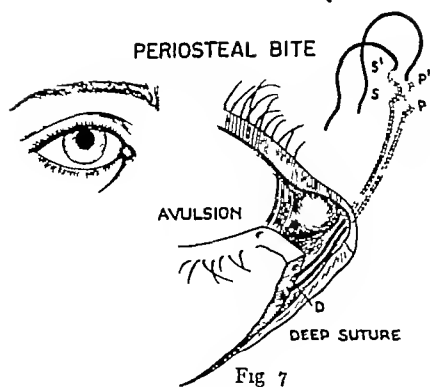


Fig 7

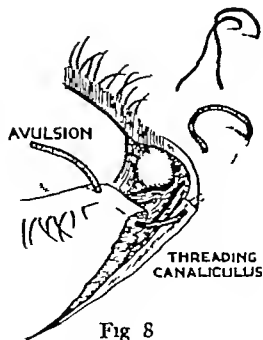


Fig 8

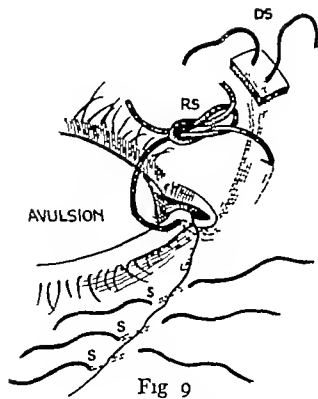


Fig 9

Fig 7 *Avulsion* Mattress suture (No 2 braided) inserted at D in posterior part of tip of tongue below the canaliculus. Needles are removed and one arm of suture is threaded on a Yankauer nasal septum needle, or button hook, Deschamp, and introduced below the caruncle at its nasal extremity. S represents the bite in the periosteum as high as one can get and S' the point of emergence from the skin. The other arm of the suture similarly follows the first at P and at P'. The suture is not tied until canaliculus has been threaded.

Fig 8 *Canaliculus threaded* A needle threaded with

heavy chromic catgut suture has entered the canaliculus at the punctum. The nasal orifice of the canaliculus, having been dilated, permits the suture to enter the sac itself. The suture emerges from the skin over it.

Fig 9 *Repair of avulsion* The suture threading the canaliculus is tied so loose that a ring of catgut results. The deep suture has had its slack taken up and is to be tied over a bolster so that the lower lid lies higher and posterior to its normal position. DS, Deep suture, RS, ring suture, S, skin closure sutures placed so that temporal bite is taken lower than the nasal.

1 The punctum is dilated moderately with a conical dilator and the canaliculus with a No 4 probe.

2 A heavy silk or chromic suture enters the punctum to emerge in the temporal raw edge of the canaliculus and continues on into the nasal stump where its orifice may have to be dilated after identification.

3 To prove communication with the lacrimal sac, a probe may be used or the sac irrigated with fluorescein through the upper punctum.

4 The needle enters the sac to emerge in the skin above the internal canthal ligament. The suture may be left loose but to avoid slipping it is better to tie it into a loose ring 2 centimeters in diameter. Proper approximation is accomplished by the deep suture, which, after the slack has been taken up, is tied snugly but not tightly over a rubber or gauze bolster.

#### REPAIR OF NOTCH OR CONGENITAL COLOBOMA IN LID MARGIN

A small notch or congenital coloboma may be converted into a laceration of the lid by incising the lid border just where the notch begins and continuing the incision into the lid substance so as to excise an isosceles triangle with the notch as its base. The edges of the wound are made bevelled so as to increase the area for adhesion. After intramarginal splinting suture is placed, conjunctiva and tarsus are repaired and skin and orbicularis closed.

When the notch is caused by the scar resulting from a badly approximated laceration, the scar is excised and the lid repaired as if freshly lacerated.

#### CONCLUSIONS

1 The vast majority of lacerations repaired in the manner here described healed so well that it was afterward difficult to determine the site of the injury. Two showed some notching due to poor healing because the patient tore off the dressings when coming out of the general anesthesia.

2 Immediate repair is indicated when there is no loss of tissue even though the wound is obviously contaminated.

3 Unless actually necrotic, no tissue need be excised, however bruised or ecchymotic. It is desirable not to straighten the edges of the laceration disregarding all irregularity, unless loss of substance interferes with proper approximation. The usual bevel of the edges should be preserved to broaden the base of adhesion. If there is to be a revision of the wound, the bevelling should be exaggerated rather than eliminated. Wiener's suggestion of making the edges of the wound concave rather than straight is an excellent one.

sacrifice health skin of the lid when it seems very scarce, in order to get such a flap of tarsus to help in the healing process. I think too much stress cannot be given to this idea. (p. 6.) (Wheeler John M. Collected Papers)

Later to repair a badly healed avulsion he divided the temporal flap of the avulsed lid into two layers, the first consisting of skin and orbicularis, the second of tarsus and conjunctiva. The second layer he anchored by a mattress suture to the raw tissue which lies posteriorly and above the inner canthal ligament. In this procedure one canaliculus was necessarily sacrificed the other being deemed sufficient for drainage of the tears into the nose. To quote from Wheeler

Traumatic coloboma of lower eyelid near inner canthus. Improper primary healing of such wound results in coloboma near the inner canthus and ectropion of the lid near the coloboma. Sutures are placed diagonally along the incision in such way as to advance the whole flap and have as little pull as possible for the sutures at the apex during the healing process. Of greater importance is the adjustment of the tissues at the apex of the flap. The small amount of skin just external to the inner canthus is carefully and completely undermined. The skin and orbicularis are stripped from the anterior surface of the tarsus so as to expose 4 or 5 millimeters of the tarsus. A suture is carried through the exposed tarsus, and then it is carried well into it so as to get a firm hold. A mattress suture mounted with two needles is carried through the exposed tarsus, then through the flap of skin which has been dissected up near the upper canthus. When the sutures are snugly tied the apposition will be secure and the lid will lie well back against the globe and well up to the proper level or even high enough to be in position of overcorrection. Without this careful adjustment and definite overlapping of raw surfaces one cannot be sure of complete obliteration of the deformity. (p. 35.)

Savin in 1940 discussing "Eye Injuries in Warfare" outlined the following pertinent general observations and made special reference to preserving the lumen of the canaliculus in avulsion of the lower lid

Blood supply of lids is exceptionally good. Extensive wound excisions, such as general surgeons tend to perform, are not necessary. Sloughing is rare. Proper alignment is essential. Leashes must not be allowed to turn in.

Avulsion. Fine silk suture is passed through the canaliculus lumen—and is entered into the medial end of the canaliculus, passed behind eyelid along its lumen and then turned forward so that the point

is brought out on the skin of the lower lid and tightened. Apposition and union readily result.

I have modified Wheeler's technique by anchoring the unsplit flap by a deep double armed suture which takes bites in the periorbital tissue above the lacrimal sac. This is done with a Deschamps needle shaped like a button hook. The temporal portion of the torn canaliculus is threaded by a heavy silk or catgut suture which is carried through the opening in the nasal remnant of the canaliculus into the lacrimal sac and brought out through the skin over it. There it is tied into a loop or bow ring to prevent its slipping. The suture follows the distortion of the canaliculus created by the deep sutures and avoid overriding of one part of the canaliculus on the other. The wound heals by first intention, and the approximated openings of the ends of the canaliculus have an excellent chance of healing without scar tissue interrupting the continuity of the lumen. The skin and orbicularis are sutured so that the bite in the nasal lip is 7 or 8 millimeters higher than that in the temporal one. A more detailed description of the deep suture technique follows.

#### Deep suture (Fig. 2)

A double armed No. 6 braided black silk suture is passed from the conjunctival side into the skin edge just below the canalicular border, 3 millimeter loop, D on the conjunctiva separating the rim of the suture.

2. The needles are removed from the suture which is threaded successively on a 1/2 inch needle or modified Deschamps shaped like a button hook. The suture is passed through the rim from the conjunctival side of the hook.

3. The tip of the Deschamps is introduced in the raw tissue from which the lid was torn, between the periorbital and overlying tarsus and carried to a point near the dome of the lacrimal sac, below the periorbital. S is picked up by the needle point and its point is felt through the skin, S'. The needle being transfixed the periorbital for about 2 millimeters is rotated by lowering of the handle.

4. A strong pair of forceps straddles the hidden needle point and impales the skin on it by lowering the handle—but more. After the end of the needle appears, the suture on its convex side is picked from the eye by forceps, and grasped by an artery clamp as the button-hook Deschamps is rotated out of the wound.

5. The second rim, P P' of the suture is threaded in similar fashion coming out through the skin 5 millimeters below the first.

Canaliculus threaded (Fig. 3.)

# THE SURGICAL TREATMENT OF BILATERAL BRONCHIECTASIS

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THE feasibility of lobectomy for bronchiectasis is now well established in instances of unilobar, bilobar, and even universal bronchiectasis of one lung. Reports from various thoracic clinics throughout the world and our personal experience justify the conclusion that operative mortality in suitable risk patients submitted to unilateral partial pulmonary resection should not exceed 10 per cent and usually approaches 5 per cent. Total pneumonectomy is more hazardous, of course, but the complete removal of one lung for bronchiectasis is not accompanied by an excessive mortality. This is particularly true if the operation is performed on young subjects. We have undertaken total pneumonectomy for bronchiectasis in 4 children under 8 years of age. All recovered. After childhood the risk of pulmonary resection increases and the mortality of total pneumonectomy for bronchiectasis in adults ranges from 15 to 30 per cent in the majority of those cases which have been reported in the literature.

Such uniform successes with modern lobectomy and pneumonectomy for unilateral bronchiectasis have established beyond question the desirability of treating the disease surgically. Unfortunately, however, at least 30 per cent of patients with bronchiectasis have bilateral distribution of the disease. A sufficient number of successful bilateral lobectomies has been reported to prove that bilateral extirpation of lung tissue can be accomplished. More experience is necessary, however, to determine which cases should be accepted for such radical surgical treatment. Although the exact precedents for recommending bilateral extirpation of lung tissue are not yet established, the principal considerations are (1) the age and general condition of the patient, (2) the amount of lung tissue in-

involved, and (3) the degree of involvement and the severity of symptoms.

## CHOICE OF PATIENTS FOR BILATERAL LOBECTOMY

*Age and general condition.* The age of the patient deserves more consideration in bilateral cases, and it is our opinion that an operation is rarely justifiable in patients past middle age with bilateral disease. The upper age limit will vary in the individual case. The great majority of candidates for bilateral lobectomy, however, will be young, since few victims of extensive bronchiectasis will survive to middle age. Cardiovascular disease and other serious conditions will, of course, preclude the possibility of lobectomy.

*Amount of lung tissue involved.* A consideration of the amount of lung tissue involved will naturally force the question of how much lung tissue can be removed with a reasonable degree of safety. The experimental work of Heuer and Andrus (4) has demonstrated that dogs live indefinitely with two pulmonary lobes. Later the same authors with their associates, Dunn, Rienhoff, Cave, and others, found that in a dog life was compatible with possession of but one pulmonary lobe.

In man the amount of lung tissue which may be extirpated safely is influenced by a consideration of vital capacity, age, and other individual factors. Reports of successful bilateral lobectomies by Eloesser, Shenstone, and later by Lewis, Churchill, and others and of a successful trilobe lobectomy by Overholt have established clinically that extensive bilateral extirpation of pulmonary tissue is feasible. Recently one of us (3) described the successful removal of even more lung tissue, namely the right middle and lower lobes, and 18 months later the left lower lobe and lingula of the left upper lobe in a boy 16 years of age. This patient is now going to school and is able to engage freely in the usual physical activities.

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4 Unless the eyeball has been perforated strong pressure is indicated to help avoid infection.

5 The repair of recent lid lacerations is achieved by a simplified procedure depending upon a suture (inserted in the plane of the gray lines of both lids) which splints one lid margin against the other prevents vertical overriding and avoids the development of a notch. Anteroposterior displacement is eliminated even when the eyeball is perforated or absent. Suturing of tarsus, tarso-orbital fascia, orbicularis and skin prevents lateral spreading.

6 When both lids are lacerated at a common point a figure-of-eight intramarginal suture is indicated.

7 In avulsion of the lid, the overcorrection is aided by a suture anchored to the pericardium above the dome of the sac by a "button hook" Deschamps needle. The torn canaliculus should be threaded by a heavy suture in an attempt to preserve the lumen.

8. A small notch or congenital coloboma can be converted into a fresh markedly bevelled laceration and repaired simply by the intra marginal splinting technique.

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FIG. 1. The eighth fatal object of lung tissue aspirated.

the pulmonary hilum to prevent the patient from drowning in his own secretions while unconscious from the anesthetic. Both of these casualties were therefore directly or indirectly caused by the flooding of the trachea during the performance of the operation despite emergency bronchoscopy in the first case and frequent bronchoscopic aspirations during the operation in the second. The third death was the result of a staphylococcus septicemia which followed a minor hemorrhage from the intercostal artery at the site of a thoracostomy tube. This occurred 6 weeks after the operation. The patient's temperature had been normal and he had been out of bed for 2 weeks before this unusual complication became evident. The death was not related therefore to the presence of bilateral bronchiectasis.

One of the most astonishing features of our cases has been the marked improvement following the removal of the bronchiectatic lung tissue on one side. Several patients have enjoyed such excellent results that they have decided to postpone the operation on the other lung. This is particularly surprising because incomplete removal of bronchiectatic tissue in unilateral cases, in our experience, resulted in complete failure of the operation to relieve the symptoms. The results in 9 patients with bilateral bronchiectasis who have had operations on one side are summarized in Table I.

Six of the 9 surviving patients are completely satisfied with the results of the initial operation and have decided to postpone the second operation indefinitely unless the amount of sputum increases. Two patients are greatly improved but are contemplating having the remaining diseased lung tissue removed. In 1 case the extirpation of the right lower lobe was followed by a left empyema thoracis and although the patient has lived for more than a year, he has failed to improve.

The oldest patient in the group (34 years old, Case 2) was operated upon because, in addition to raising foul sputum, he was completely incapacitated by an intractable cough caused by a partial stenosis of the right lower lobe bronchus. From the patient's standpoint, an entirely satisfactory result was obtained by unilateral lobectomy.

It should be emphasized that the best results from unilateral operations in patients with bilateral disease were in patients with far advanced disease on the side operated upon and the less severe disease in the contralateral lung. There was, however, marked improvement in all but 1 case after the first operation regardless of the degree of involvement of the two sides.

In 11 of the 16 patients hipiodol bronchography revealed involvement of both lower lobes, the right middle lobe, and the lingula of



Fig. 1. Photographs of patient 3 months after removal of both lower lobes, the right middle lobe, and lingula of the left upper lobe.

without dyspnea or any other physical handicap. Experience with 16 other cases of bilateral bronchiectasis including 4 patients in whom all of the lung tissue was removed except the two upper lobes (the lingula of the left upper lobe was also removed and here after will be regarded as the left middle lobe) has convinced us that in young subjects two pulmonary lobes furnish adequate respiratory exchange for ordinary physical activities.

*Degree of involvement and severity of symptoms.* It has been shown by Perry and King and others, that the severity of symptoms in the individual case of bronchiectasis will almost always parallel the degree of involvement in the bronchiectatic lung; that is in general the amount of purulent sputum is in direct proportion to the degree of the bronchial dilatation. The decision to recommend bilateral lobectomy will therefore depend somewhat upon the amount of sputum raised and the inconvenience and disability that the production of foul sputum causes the patient.

In patients of the older age group with bilateral disease and mild symptoms, postural

drainage should be given a fair trial before surgical treatment is undertaken. In certain cases, postural drainage may be supplemented by bronchoscopic aspirations. It is our opinion however that in young subjects radical treatment is practically always desirable. Children tolerate intrathoracic operations particularly well, and for obvious reasons it is desirable to eradicate the disease before irreparable physical and psychological damage is done.

#### RESULTS IN 16 CASES OF EXTENSIVE BILATERAL BRONCHIECTASIS

In the group of 16 cases bilateral pulmonary resection was performed in 4 cases. In each of these patients the disease involved all of the pulmonary lobes except the two upper lobes (the lingula of the left upper lobe was also diseased and removed). Two of the patients were 16 years old, one 10, and the other 9. One patient, 16 years old, in whom the right lower and middle lobes had been removed 2 years before the second operation died 3 weeks after the left lower lobe and lingula of the left upper lobe were extirpated. In the bronchiectatic lingula of the left upper lobe removed at operation there was evidence of acute tuberculosis. Death was caused by acute tuberculous pneumonia. The lobes removed at the first operation were re-examined and there was no evidence of tuberculosis. The original diagnosis of bronchiectasis was made by competent physicians at a tuberculosis sanatorium where the patient was and because of a chronic productive cough. He returned to the same institution to convalesce from the first operation. Apparently pulmonary tuberculosis developed during the interval between lobectomies and was activated by the second operation.

In the 12 remaining cases in which the most severely diseased side was operated on there were 3 deaths, 1 from suffocation on the operating table as a result of sudden flooding of the trachea. Another followed the development of a putrid empyema, the consequence of the opening of the bronchus on the second postoperative day. The early leak in the bronchial stump was undoubtedly the result of hurried operating with gross mass ligation of



Fig. 2. c, Photograph of pulmonary tissue removed

the left upper lobe. In the 5 remaining patients the distribution of the disease was as follows: left lower lobe and right middle lobe, 1 case; left lower, left middle (lingula), and right middle lobe, 2 cases; and both lower lobes, 2 cases.

Our practice has been to eradicate the involved lung tissue on the side most extensively diseased and attack the other side later. In a few cases it was rather difficult to decide which lung was more extensively diseased by the appearance of lipiodol bronchograms. The impressions gained by bronchoscopic examinations were relied upon to determine the major source of pus in these cases (Fig. 2).

#### THE PRINCIPAL HAZARDS OF BILATERAL PULMONARY RESECTION

**Suffocation.** The principal immediate risk of pulmonary resection, whether it be for unilateral or bilateral bronchiectasis, is suffocation during the performance of the operation. The bronchiectatic lung tissue constitutes a cesspool of putrid secretions whose only exit is through the tracheobronchial tree. If the disease is bilateral, two reservoirs of purulent secretions must either drain through the trachea or remain pooled in the lung. The trachea is in fact a relatively small caliber tube, yet it is the only airway through which the respiratory exchange can be maintained.

During the administration of an inhalation anesthetic, it is also an essential passageway for the anesthetic gas. The head-down position is advantageous for postural drainage in the conscious patient and does aid in emptying the lungs of pus as long as the cough reflex is intact. Lowering the head of an unconscious patient whose lungs are filled with secretions, however, increases the danger of suffocation by flooding the trachea. It becomes apparent, therefore, that the conventional lobectomy position with the head and trunk lowered to the horizontal level, has two distinct disadvantages: (1) secretions will gravitate into the trachea and interfere with the administration of the anesthetic agent, (2) the contralateral or "good" lung is dependent and its bronchial orifices in a position to be flooded by the secretions during the time it must carry the major load of respiratory exchange (Fig. 3).

Experimental work by Schlaepfer, illustrating the increased danger of fatal air emboli when air is injected into a pulmonary vein with an animal in an erect or semierect position, has undoubtedly influenced thoracic surgeons to perform operations with the patient's head and trunk lowered to minimize the danger of the influence of gravity if air embolus should occur. It has been demonstrated by Moore, however, that the chief source of danger from air embolus is not to the cerebral





b

Fig. a and b, Lipiodol bronchograms showing extensive bilateral bronchiectasis. Bronchoscopic examination gave the impression that more pus was originating in the right, a, than in the left, b, lung. Accordingly the right

middle and lower lobes were removed first. Three months later the left lower lobe and lingula of the left upper lobe were resected. A photograph of the patient, ten weeks after the second operation is presented in Figure 5.

TABLE I—RESULTS IN 9 PATIENTS WITH BILATERAL BRONCHIECTASIS WHO SURVIVED OPERATIONS ON ONE SIDE

Case No.	Age	Lobes removed	Lobes retained	Results and comments
1		Both lower lobes Right middle lobe Lingula of left upper lobe	Left lower lobe Lingula of left upper lobe	Asthenia reduced from 100 to 70 cc. in 1/2 hour
44		Both lower lobes Right and left middle lobes Lingula of left upper lobe	Right lower and right middle lobes	Intractable cough relieved. Asthenia reduced from 100 to 10 cc. in about 10 days
50		Both lower lobes Right middle lobe Lingula of left upper lobe	Right lower and right middle lobes	Asthenia reduced about 50 per cent. Pus from left side operative. Probably will require operation on left side
52		Both lower lobes Right middle lobe Lingula of left upper lobe	Left lower lobe and lingula of left upper lobe	12 months free for 1 year, except for 10 cc. of sputum each morning
58		Both lower lobes Right middle lobe Lingula of left upper lobe	Right middle and lower lobes	10 cc. of sputum daily since operation. 100 per cent reduction in sputum since operation
113		Left lower lobe Right middle lobe	Left lower lobe	Small amount of sputum (about 1 ounce) since operation
119		Left lower lobe Lingula of left upper lobe and right middle lobe	Left lower lobe and lingula of left upper lobe	Left report about 100 cc. Small amount of sputum (non-creta) in the morning. Produced large amount of foul sputum before operation
126		Left lower lobe and right middle lobe	Left lower lobe	Practically no sputum for 1 year after the operation. Sputum now about 10 cc. daily
		Both lower lobes	Right lower lobe	7 years. Developed emphysema on left. Could not be put to rest with second operation

Before the upright position was employed in unusually wet cases we placed a large premium on speed in operating upon patients with bilateral disease. We have been gratified to find that in patients who remained upright sufficient time was available to accomplish separate ligation of each structure in the pulmonary hilum. This is of tremendous importance in dealing with bilateral bronchiectasis because a leak in the bronchus immediately or soon after the operation constitutes a much more serious problem in patients with bilateral disease than in individuals with a sound contralateral lung. Actually the ultimate success of the operation, particularly the first one, may depend on a rapid and smooth convalescence.

#### POSTOPERATIVE CARE AND COMPLICATIONS

In patients with bilateral bronchiectasis re-expansion of the remaining lobes becomes of tremendous importance particularly at the time of the second operation. The respiratory exchange must depend upon the upper lobes and failure of re-expansion or atelectasis might



Fig 4 Photograph of a patient in the upright position for lobectomy



Fig 5 Temporary manual immobilization of the thoracic cage to aid coughing, an important feature in the postoperative care of lobectomy patients

be fatal. We have maintained, therefore, an upright position during the postoperative period, thus keeping the pleural cavity on the side operated upon completely free from fluid by catheter drainage with suction. This allows the remaining lung tissue to re-expand rapidly. Placing the patients in a horizontal position with the side operated upon down and thereby allowing dependent drainage is not desirable in instances of bilateral disease because secretions from the contralateral lung will collect in the trachea. The remaining lung tissue has expanded within a few hours when the upright position is maintained, and we find that the patients are more comfortable when upright.

The other features of the postoperative care involve attention to the same details which are important following any major thoracic operation.

Routine postoperative bronchoscopy before the patient reacts from the anesthetic is of paramount importance. In this way the secretions which have accumulated in the contralateral lung during the operation can be partially emptied. Temporary immobilization of the thoracic cage, during the act of coughing, as soon as the patient is awake, may



FIG. 3 a. A lipiodol bronchogram demonstrating distribution of 5 cubic centimeters of lipiodol with the patient in the upright position. b. An X-ray film of the same case 5 minutes after being placed in the position usually employed

for lobectomy. The oil has flowed into the trachea and dependent lung. In patients with "wet" bronchiectasis of location may be caused if pos is allowed to accommodate the trachea and contralateral lung. This is particularly true when the chest is opened widely during the performance of intrathoracic operations.

vessels but the collection of air in the coronary vessels of the heart. The same conclusions were reached by Kent and Blades who repeated Moore's experiments and also found that the position of an animal had little or no effect when air was injected into the pulmonary veins. Moreover air embolus from lobectomy is a relatively infrequent accident as compared to the complications caused by suffocation from flooding the trachea and dependent lung when the conventional position for the operation is employed.

#### THE UPRIGHT POSITION FOR LOBECTOMY

The decision to perform a lobectomy with the patient in the upright position to minimize flooding of the tracheobronchial tree was made by strict necessity in a patient who could not tolerate a completely flat or horizontal position when fully conscious. It was even necessary to perform preoperative bronchoscopies in an upright position to prevent suffocation. Bilateral extirpation of all lobes (including the lingula of the left upper lobe) except the two upper lobes was accomplished in two stages without difficulty and the pa-

tient enjoyed an uneventful convalescence after both operations (B-B) (Fig. 4).

Since the surprising success in this difficult case the upright position has been employed on 7 occasions in extremely "wet" cases and it has been possible to proceed with the pulmonary resection with deliberate and preoperating unhampered by frequent aspiration through the intratracheal catheter or by the necessity of an emergency bronchoscopic aspiration to prevent suffocation. Technical difficulties are not increased and the exposure is excellent. The usual posterolateral incision has been utilized with a technique identical to that employed when the patient is in the conventional horizontal position.

One logical objection to performing a major operation with the head raised might be the danger of shock. Surgical shock was not manifested in any of the 7 patients operated upon in the upright position. If however it should occur it would be safe to lower the head and trunk provided facilities for bronchoscopic aspiration were immediately available to decompress the trachea when the position of the patient was altered.

# END-RESULTS IN ONE HUNDRED CONSECUTIVE CASES OF BRAIN ABSCESS

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THE three problems to be solved in an attack upon a brain abscess are when, where, and how to operate. Increased clinical experience with this lesion plus the use of ventriculography and other technical aids have made diagnosis and localization relatively simple. But determination of the proper time to attack an abscess and selection of the appropriate procedures for drainage requires the nicest surgical judgment. Only too often the initial feeling of satisfaction in the surgeon's mind over an apparently successful outcome is abruptly shattered by the appearance of some unexpected and possibly disastrous complication.

A study of the records of one hundred consecutive cases of subcortical abscess of the brain seen in the neurosurgical clinic of the University Hospital form the basis of this report. Little stress will be laid upon etiology, types of organism, or methods of diagnosis and localization unless these factors bear directly upon the surgical results. These cases were seen between January 1, 1926 and January 1, 1940. An adequate follow-up over a number of years is, therefore, available in many of the survivors.

Of these 100 cases, 47 recovered and 53 died. Ten patients died before any operative procedure could be instituted, 7 within 12 hours of admission to the hospital, 3 within 48 hours. These last 3 cases were all seen prior to 1930 when the value of ventriculography in the localization of the lesion was less clearly recognized. Nine patients had meningitis as indicated by lumbar puncture findings prior to operative intervention. Surgical attack upon the abscess was undertaken as a last resort. In 6 evacuation was successful and in 3 the lesion was found at autopsy. All of these fatalities occurred prior to 1937. The use of the appropriate sulfaderivatives, had they been avail-

able, might well have saved half of this group. In 9 patients multiple abscesses were present. One or more of these lesions were adequately drained in 7, in 2 the evacuation of pus was unsatisfactory. In 7 of these patients the abscesses were so widely separated, parietal and cerebellar, frontal and occipital, right and left frontal, frontal and parietal (3), right and left cerebellar, that formation of a second adjacent abscess following bad drainage of the original cavity seemed impossible. In 2 cases, one of multiple frontal and another of multiple cerebellar abscess, it is conceivable that inadequate drainage of the primary abscess may have resulted in a spread of infection and the formation of a second cavity. The 25 remaining fatal cases are grouped together under the general heading of "bad operative technique" as the cause for the mortality. It is from an analysis of this group that we hope to find the errors in operative methods. In all these cases the surgeon had every opportunity to save the patient, in none was any great emergency present, and the operative procedure was planned and carried out deliberately in the manner he considered to be the best adapted to the problem at hand.

What are the particular problems connected with the surgery of brain abscess? The brain lies within the close confines of the skull, therefore, an increase in intracranial pressure may appear before or after operation and must be promptly and adequately relieved. The entire brain is surrounded by the sub-arachnoid space containing the cerebrospinal

TABLE I — 100 CASES BRAIN  
ABSCESS VERIFIED

	Cases	Per cent
Died	53	
Recovered	47	
Not operated upon, died	10	19
Causes of death		
Meningitis before operation	9	17
Multiple abscesses	9	17
Bad surgical management	25	47

TABLE II.—OPERATIVE STATISTICS

	Dead	Recovered	Percent
Closed drainage	6	33	66
Open drainage	6		66
Evacuation	3	3	50
Totals	5	47	

TABLE III.—OPERATIVE TECHNIQUE  
47 RECOVERIES

	Cases
T p and drain	24
Tap only	8
Wide drainage	
Evacuated	3
Total	47

fluid. Furthermore those areas of the brain overlying the abscess must be traversed by the drainage tract. Again the abscess may tend to burrow down toward and rupture into the ventricle. Prevention of infection either before or after drainage therefore is a problem. Lastly since certain cortical areas of the brain overlying many an abscess have important functions, evacuation of the cavity with a minimum of destruction of the cortex is essential if recovery without motor or sensory loss is to be accomplished.

All neurosurgeons agree that if possible an abscess should not be attacked until encapsulation has occurred. Three to 4 weeks from the onset of symptoms, therefore, should be permitted to elapse before the cavity is evacuated although that certain abscesses will never become encapsulated is frankly conceded. The use of sulfadimethoxyls has largely overcome the dangers of infection. The proper way to handle the problem of increased intracranial pressure and the amount of destruction of adjacent brain tissue and overlying cortical areas justifiable to secure adequate drainage are the outstanding points at issue. If intracranial pressure is to be relieved and adequate open drainage of the abscess under direct vision assured a large opening must be made in the bone and overlying cortical areas and brain tissue adjacent to the abscess destroyed. This may well result in impairment of function and the large scarred area in the brain may subsequently cause convulsive attacks. But if only a small trephine opening is made the abscess simply tapped and drained to minimize injury to the surrounding brain the drainage may be inade-

TABLE IV.—CAUSES OF DEATH  
AFTER CLOSED DRAINAGE

	Cases
Increased pressure	1
Cerebritis	1
Meningitis	1
Total	3

TABLE V.—CAUSES OF DEATH  
AFTER OPEN DRAINAGE

	Cases
Meningitis	1
Cerebritis	1
Vascular injury	1
Total	3

TABLE VI.—CAUSES OF DEATH FOLLOWING  
"BAD OPERATIVE TECHNIQUE"—25 CASES

	Cases
Cerebritis	1
Meningitis	1
Increased pressure	1
Vascular injury	1
Total	4

TABLE VII.—COMPARISON OF RESULTS IN  
"CLOSED AND OPEN TECHNIQUE"

	Cases
Cases followed	47
Dead	1
Lost	1
Closed technique	
Tapped or tapped and drained	26
Complete recoveries	22
Complication	1
Open technique	
Wide drainage	12
Complete recoveries	1
Complications	1

quate or the intracranial pressure perished with fatal results.

Curiously enough in this series, 48 cases were handled by a closed drainage with 31 recoveries and 16 deaths, a 33 per cent mortality while 18 cases had a larger opening made for open drainage with 12 recoveries and 6 deaths, a 33 per cent mortality. The advocates of open drainage may well claim that had more of the 48 patients treated by closed drainage been widely opened the mortality might have been lower. In this group of 16 fatal cases, in 6 following tap and difficulty in insertion of the drainage tube autopsies showed a marked cerebritis about the abscess. In every instance the abscess was deep seated, small and encapsulated. Five of these lesions were cerebral: 1 right frontal; 1 right temporal;

1 left frontal 2 in the left temporal region, and 1 in the cerebellum. Admittedly these small deep seated encapsulated lesions are hard to handle by any method. The left frontal and temporal areas are too important physiologically to justify free excision. A cerebellar abscess is difficult to drain widely because of the heavy muscles attached to the occipital bone. The two lesions in the right cerebral hemisphere might have been saved by section of the cortex. In 7 patients with relatively superficial lesions apparently adequately drained by simple trephine, death was attributed to increased intracranial pressure, on clinical evidence in 4 instances and at autopsy in 3. Two of the 3 cases at autopsy had cerebral, 1 a cerebellar abscess. No meningitis was noted nor was there an unusual amount of cerebritis present about the lesion. The striking feature in each case was a pressure cone about the cerebellar tonsils. Admittedly these 7 cases might have been saved by a wider opening in the bone with cortical section and more ample drainage or by the addition of a contralateral decompression to the operative procedure for the purpose of reducing intracranial pressure. In 3 instances postoperative meningitis was the cause of death, due in 1 case to rupture of the abscess into the adjacent ventricle, and in 2 to infection presumably of the subarachnoid spaces about the drainage tract.

The 6 deaths following open drainage with a wide craniectomy and cortical incision, all in cerebral lesions, were caused in 2 instances by the development of uncontrollable brain fungus, meningitis in 3 patients, and inanition in a single case after a 3 months' struggle.

The 3 fatalities consequent upon an attempt at complete enucleation of the abscess were due to meningitis consequent upon its rupture during removal in 2 instances. In the third, a large, chronic, encapsulated abscess of the left middle fossa, the middle cerebral vessel was adherent to the lesion and was torn during its removal. The wound healed well, no meningitis could be demonstrated, but the patient died about 2 months later as a result of the vascular injury.

Of the 47 patients that recovered, 24 were tapped and a drain inserted, 8 were tapped

without permanent drainage. In 12 wide drainage by craniectomy and cortical section was instituted. In 3 complete enucleation of the abscess was successfully accomplished.

This brief review of the surgical methods used suggests definitely that the tendency here has been toward conservatism as to the destruction of brain areas overlying or adjacent to the abscess in establishing drainage.

In support of this conservatism the follow-up statistics furnish important information. Forty-one cases have been followed, 4 are lost, and 2 are known to be dead from outside causes. Among 29 cases treated conservatively by tap or tap and drain, 22 have completely recovered and, as far as our information goes, have returned to their original economic status. Seven patients have neurologic sequelae, weakness or convulsive attacks which have seriously crippled their wage earning power. In 12 patients in whom deliberately or through necessity a craniectomy was performed with cortical destruction for more adequate drainage, but 3 have made complete recoveries, and 9 have sequelae of such a nature that they are seriously handicapped economically.

As a result of this study the conclusion seems unavoidable that conservative treatment tap or tap and drainage through a small trephine in the bone, produces the better results in the long run in the treatment of brain abscess. The use of wide open drainage has not, in this series at least, lowered the operative mortality in comparison with more conservative methods. A careful follow-up in this group of cases indicates that a much higher proportion of patients are returned to their former occupation following the use of simpler procedures for instituting drainage than when a more radical technique involving wide destruction of brain tissue is employed.

We feel, therefore, that the initial attack upon a brain abscess should be carried out through a small trephine opening with the insertion of a drainage tube. This will result in a cure in many instances. If this technique does not produce satisfactory results, a resort must be had to more radical methods involving the patient in a greater hazard from serious neurologic sequelae.

# MECHANICAL SKELETAL FIXATION IN WAR SURGERY

## Report of Sixty-one Cases

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WAR conditions do not create new or unknown fracture problems—but they will often multiply the problems of the individual patient. During the course of a year every imaginable type of fracture is likely to be seen in a busy civilian hospital but among war casualties, frequently the complicated fractures occur in combination which greatly increase the difficulties of treatment. On top of this the theater of war comprises an environment less favorable for treatment than exists in civilian hospitals. The operating rooms are less adapted to careful asepsis, the crowding of patients on wards threatens a higher rate of cross infection and the personnel of hospital staffs may be more pressed for time by the rush of cases, and may in themselves be less efficiently trained than would be desired under normal conditions. Consequently the problems of war surgery arise largely from the combination of these two factors: multiplicity of complicating injuries and less favorable environment for treatment. Under these circumstances, we may tend to adopt slightly more radical methods of treatment, but before doing so we must insist upon one elementary point. We must be sure the pretext of emergency conditions does not lead us into the fatal error of adopting an easier method rather than a better method. If we change to radical measures, we must make certain that they are reasonable measures. Even critical stages of war the principles of our treatment must be kept sound.

These considerations were kept in mind in 1930 when among the equipment provided for the American Hospital in Britain was included apparatus for the mechanical skeletal fixation of fractures of the types devised by Roger Anderson and Hansen. As the apparatus had never before been used for the treatment of air raid and battle casualties, it was felt that the indications and contraindications for its use must be carefully studied. It was recognized that the apparatus

offered many possibilities for improving the treatment of difficult cases. At the same time the possibility of misuse or abuse of the method was appreciated. In general two rules were applied as guard against this latter danger. The first, and most important rule, insisted that the apparatus was to be applied only by qualified surgeons who thoroughly understood the principles on which it was based and had carefully studied its mechanism. Not all of the staff had had personal experience with its use but all had familiarized themselves with its practical workings as well as theoretical purposes. Unless this point is stressed the use of the apparatus is likely to prove more dangerous than beneficial. Second, the rule was adopted that the method should be applied only to cases in which treatment by simple or conservative lines seemed likely to prove inadequate. In other words, mechanical fixation was to be used routinely or universally but was reserved for selected cases. Here again, the point to be stressed, that a thoughtless and indiscriminate use of this method would be wholly unwarranted. Like any other method of treatment, its success depends entirely on the judgment and the skill of the surgeon who employs it, for no matter how mechanical it may appear it cannot pretend to convert the art of surgery into a machine to be

The principles behind mechanical skeletal fixation and reduction were originally based upon very sound reasoning and have already been presented in the literature. Many appliances have been designed to carry them out—all more or less derived from the underlying purpose of fixing the injured bone above and below the fracture by means of pin units. The pin units make possible a mechanical reduction with the most efficient utilization of the reducing forces, and with greatly increased accuracy. Once the reduction is obtained, the pin units can be fixed together by means of plaster or of bars which lock them into a single immovable vice. Thus they prevent further motion at the fracture site without necessitating the immobilization of joints above or below the injury.

A discussion of the mechanism by which this is accomplished would go beyond the scope of this

The work reported here was carried on with the help of the staff of the American Hospital in Britain, including Wallace Cole, professor of orthopedic surgery, University of Minnesota; Frederick W. Watkins, W. Richard Fargnoli, Donald F. Deal, Herman Egel, Harry Hall, Dudley Smith, James Richmond.

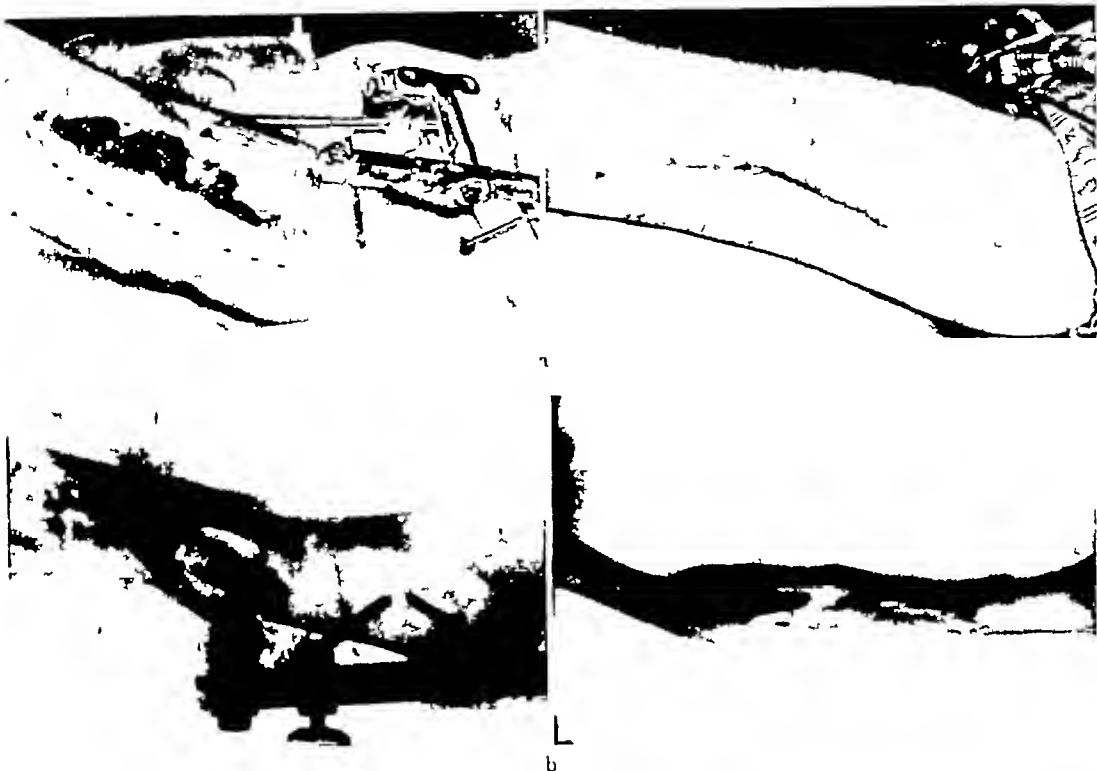


Fig. 1 a, External aspect of through and through wound of the thigh which was caused by bomb fragment—deeply infected by staphylococcus, streptococcus, and *Bacillus welchii*. Dotted line shows the original area of the wound. Left photograph shows healing after 3 months. Second photograph shows the same wound with complete

epithelialization after 6 months. Treatment was carried out by means of Anderson pins and plaster, with bar for fixation. b, Gross shattering of femur is shown in left roentgenogram. View on the right shows healing (without bone graft), as callus united across splintered fragments in a period of 6 months.

present article, but it may be said that in the cases treated by the staff of the American Hospital, the Anderson apparatus was largely used. It had the dual advantages of being comparatively easy to apply and control and of having a universal adaptation to many different varieties of fractures. A number of cases in this series were treated by Haynes' apparatus, which also gave excellent results. In addition, the principles of the Anderson apparatus were adapted by Winknitz to a miniature device for use on small bones, and in 6 cases this Winknitz apparatus was used. All in all, it seems clear from our experience that the technical aspect of equipment for mechanical skeletal fixation is still in its infancy and that great improvement may be expected along these lines.

#### APPLICATION TO INFECTED FRACTURES

Among the fracture complications which occur in war surgery, three common types will prove

especially difficult to handle by any of the established forms of treatment. The first of these groups, and the commonest, is the deeply infected compound fracture. In cases in which there is no tendency toward displacement, such fractures may often be treated satisfactorily with Orr's closed-plaster technique, and prolonged, undisturbed immobilization will almost always yield good callus. On the other hand, if the fracture is comminuted or so oblique that it tends to slip, the simple closed-plaster treatment will end in malposition and malunion. No external splint can be relied upon to prevent displacement. Such fractures, therefore, would justify open reduction followed either by plating or bone grafting, but the presence of infection contraindicates this procedure almost completely. The only adequate method of treatment left among conservative measures, is the use of skeletal traction, but this in itself entails three serious hazards. Even when combined with the use of a plaster casing, any



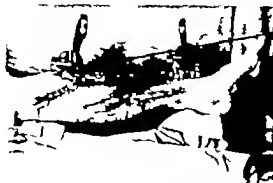


Fig. This double, compound fracture of the tibia and fibula left an anterior wound which could not be drawn together. The fracture, as fixed in perfect alignment by Anderson pins and sliding skin flap, as carried up to close the wound. A week later the area on the medial aspect of the calf, as covered by free skin graft as shown in this photograph. The procedure did not disturb the fracture reduction which was held by traction bar.

form of traction must necessarily involve motion and irritation at the fracture site, inasmuch as the weight at the foot of the bed is counterbalanced by the patient's body weight. The patient moves about in bed and no matter how well balanced his traction may be he is persistently pulling and upsets the tension upon the fracture site. This constitutes a repeated and more or less incessant violation of Orr's principle of complete rest, and thus tends to prolong the activity of the infectious process. Then also the fact that alignment has to be maintained by traction suggests that there will often be a recognizable factor of distraction whenever the pull and counterpull are altered by body movements. Since infected fractures are notorious for their high incidence of nonunion this distracting tendency must be regarded as a really serious risk. In many cases it may even be the true cause of the nonunion, unless it is properly checked by the most vigilant care aided by frequent x-ray control, neither of which may be easily available in emergency military hospitals. The third disadvantage of applying traction to infected fractures is that it necessitates a total immobilization of the patient's whole body and thereby wastes all his muscles, decalcifies his bones, depresses his metabolic processes, and invites the formation of urinary calculi. Experience among a number of such bedridden patients has convinced all of us that this danger is more than a theoretical one and that it must be actively guarded against.

The use of mechanical skeletal fixation in such cases offers many advantages. The pins can be

# STATISTICAL ANALYSIS OF SIXTY-ONE CASES TREATED BY MECHANICAL FIXATION IN THE AMERICAN HOSPITAL

TABLE I—CASES WITH EXISTING INFECTION PRECEDING PIN FIXATION

Cases	Cum
Infection definitely present but not a major complication	
Infection present as a serious major complication	
Total	1

TABLE II—AGE OF FRACTURE AT TIME OF TREATMENT

Cases	Cum
Early—up to 1 week	
Intermediates—from 2d through 4th week	2
Late—from 5th through 6th week	
Delayed union established—from 3 mos to 1 1/2 mos	1
Correction of malunion—4 mos old	
Total	3

TABLE III—ANATOMICAL DISTRIBUTION OF CASES

Cases	Cum
Long bones of lower extremity	
Femur	2
Tibia/fibula	1
Long bones of upper extremity	
Humerus	1
Forearm	
Miscellaneous	
Mandible	1
Metacarpal	1
Total	3

TABLE IV—INCIDENCE OF INFECTION FOLLOWING PIN FIXATION

Cases	Impetigo-like drainage caused with removal of pins	Infection in joint	Infection in soft tissue	Infection in bone
43 clean cases	Common here soft tissues pulled on pins	None	—	—
6 cases with pre-existing infection (minor)	None	None	6	
2 cases with pre-existing infection (major)	None	None	7	1

applied above and below the infected fracture site, and enough clean skin surfaces can usually be found on one side of the limb or another to permit this introduction aseptically. It might first be supposed that infection could spread through lymphatic channels and contaminate the

pin tracts. However, this danger does not materialize if the pins are properly applied. The design of the Anderson pins from converging angles, makes it impossible for them to pull in or out through the cortical bone. Thus any irritating motion or instability is eliminated. In fact, such dual pin units are much safer, from the standpoint of infection, than single Steinmann fixation pins whose tendency to slide back and forth is unchecked. In our experience many of the latter, which were sent in to us from other hospitals, formed infected sinus tracts which took months to heal, whereas the dual pin units, with only one exception, healed within a day or two of the withdrawal of the pins. However, if the dual pins are improperly applied and fail to pierce both cortices of the bone, they will then develop a certain amount of motion which duplicates the danger of the single Steinmann pin.

Once pins have been applied and locked together with a bar, the fracture has gained the complete immobilization needed to protect against irritation of the infectious process (Fig 1). The soft tissues can then be given the protection and support of a plaster cast, which will assure the fullest advantage of the Orr treatment. Whenever it becomes necessary to change the cast, in the course of weeks or months, the pin units, fixed to their bar, will continue to protect the fracture itself against any disturbance. On the other hand, if the occasion should arise for dressing the wound, or even applying a skin graft (Fig 2), the use of pins and bar renders the fracture easily accessible without in any way endangering its position. For surgeons who prefer repeated antiseptic dressings rather than closed-plaster treatment, this is a very great advantage. In one of our cases, drainage from an already infected fracture site became blocked and the infection flared up while pins were in place. Without interfering with the pins, it was possible to incise the mouth of the sinus and evacuate a large abscess cavity around the fracture. Pin fixation was continued uninterrupted, and both the sinus and the fracture eventually healed.

#### APPLICATION TO SHOCK CASES

It will often happen that the fractures of war surgery will be complicated by moderate or severe shock. This may arise from simple loss of blood, or from associated injuries in the head, chest, or abdomen. Or it may be that multiple fractures have occurred and have caused excessive hemorrhage into the muscles. One such case in our series, suffered from 17 fractures, and the hemorrhage into his soft tissues was so extensive



Fig 3 The photograph shows anterolateral line of incision for bone grafting a fractured femur which was 6 months old and showed no sign of union. Pins were inserted posterolaterally—out of the way of the operation. Roentgenogram shows ilial bone graft in place. Solid union occurred in 4 months during which time the patient was ambulatory.

that his red blood corpuscles had fallen to 2,000,000 and his hemoglobin to 45 per cent. In such cases, any indications for operative treatment by open reduction must be followed with extreme caution, and very often must be postponed for weeks at a time. During the interval of delay, the use of spica casts for immobilization is often impossible, while at the same time treatment by traction greatly complicates bed-care and fails to make the patient comfortable. The use of mechanical fixation, however, involves practically no surgical risk. Pins can be applied if necessary, without even moving the patient out of bed. Once the pins are locked to the fixation bar, the pain of the fracture is relieved and the patient is free to move about in bed. If some other form of surgery does become necessary, the fracture itself no longer proves to be any problem or contraindication.

Often the patient is too weak at the start for a painstaking reduction of his fracture, but with the use of the fixation bar a simple, primary reduction can be carried out and locked in place. This will counteract further shortening due to muscle spasm, and will eliminate the shock that results from motion of the fracture ends. Thus



b



d

Fig 7. Snapshots of patients using mechanical fixation apparatus. b, This soldier has fractured femur as well as tibia and fibula. The group includes patient in wheelchair who had lost his left arm as well as shattering his right femur and who learned to walk with one crutch and became ambulatory 6 weeks after plaster fixation.

immediate relief is administered, with the advantage that at a later stage the limb can again be placed in the reducing apparatus and the alignment improved often without the necessity of an anesthetic, and the reduction can be completed extremely simply proceeding on from the primary plaster fixation which has already been performed.

In the meanwhile the patient's fracture has been completely immobilized and he has been rendered more safely transportable than by any other method could accomplish. From this standpoint, the use of the fixation brace is most important adjunct to treatment, and has a great advantage over simple plaster casting.

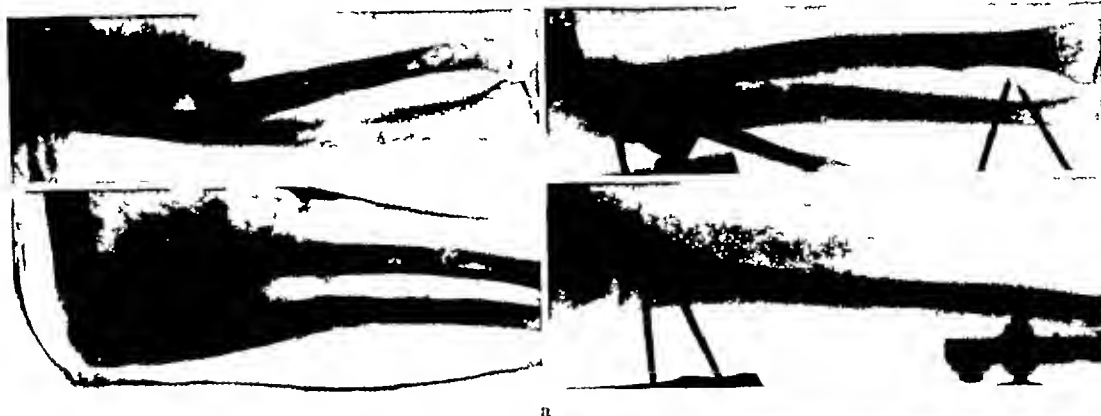
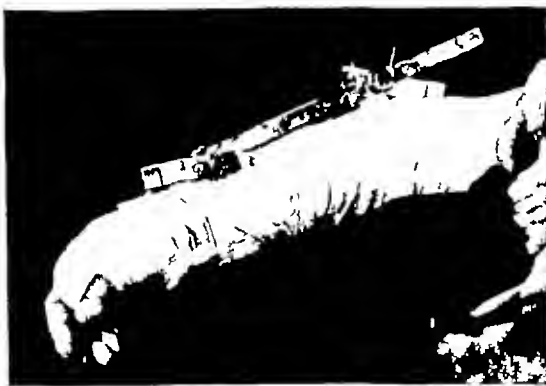


Fig 5 a, Dislocation of head of radius and fractures of radius and ulna which had resisted two previous attempts at simple closed reduction but yielded easily to mechanical reduction. Elbow was immobilized in plaster for 3 weeks following which free motion was allowed and nearly normal range was gained. Pins were removed after 12 weeks, when callus was solid. Full elbow motion was then regained almost at once. b, Same patient with arm encased in plaster-of-Paris but with external fixation bar.

#### APPLICATION TO OLD, DEBILITATED PATIENTS

Under war conditions, not a few cases will be found when the patients have suffered almost as much from their fracture treatment as from the fracture itself, and this, without criticism of the surgeons or Casualty Clearing Stations where they have previously been treated. Facilities for adequate treatment of difficult fractures may not be available at the smaller centers, and at the same time opportunities for transfer may be hard to arrange. The inevitable result is that weeks or even months may pass before the patients reach a place of final treatment. Table II of our charts illustrates the fact that only about one quarter of our series of patients reached our base hospital within the first 2 weeks. The largest proportion were therefore already in a stage in which fractures become relatively difficult to correct. Of this group, it will be noticed that almost one-third were approaching the stage of delayed union. The debility associated with prolonged rest in bed has already been noted, and is increasingly important as the months go by. As well as being a physical handicap, it also becomes a mental and moral discouragement. At this stage, it is common for surgeons to accept the necessity of grafting the bone, but after a grafting operation has been performed a further period of long immobilization in plaster spicas often proves necessary and in itself detracts from the chances of success. On the other hand, the use of mechanical pin fix-



b

ation combined with bone grafting will provide sufficient stabilization to encourage callus formation, while at the same time, the patient immediately becomes ambulatory. This treatment is illustrated in Figure 3, showing a patient with a 6 month old fracture which was first pinned to permit him to become ambulatory, and then grafted with a piece of the ilium. During the post-operative months he continued to be ambulatory and his general condition and muscular development improved, while he gained solid union of the fracture.

At first we questioned the amount of ambulation which would be possible while the patients were wearing apparatus, but in practice, our doubts were soon dispelled. One of our patients, a Polish sergeant pilot, with fractures of both bones of his lower leg, as well as his femur, made a practice of walking three-quarters of a mile up to a mile and one-half daily with crutches. This started 3 weeks after pins were inserted and continued throughout his convalescence. A number of these patients were transferred to convalescent



Fig. 6. Old malunion of 4th metacarpus, treated by the Walsky apparatus. Patient also had fractured ankle, but was able to use this hand for crutches throughout convalescence. He also stitched his browney for occupational therapy with this (right) hand.

bones for much of the convalescent period, and all of them were ambulatory to a degree that would have made their immediate evacuation to other hospitals matter of the greatest ease (Fig. 4). This factor in war surgery proves of great importance, especially with respect to femoral fractures which are so helpless when tied to Balkan frames. Reports from the British army's evacuation of France show that most of their femur cases had to be left behind to be taken prisoners.

#### DISCUSSION OF APPLICABILITY TO DIFFERENT BONES

The advantages of mechanical fixation in general apply with particular force to fractures of the femur (see Table III). Though we realize that these fractures can be successfully treated by simple traction, it must be admitted that a high percentage of failures and of delay in union does occur. This will be especially true under war conditions where a strict watch over the patient and continued x-ray control may not be easy to provide. In civilian practice many surgeons advocate open reduction of these fractures, but even this does not yield the advantage of ambulation.

More and more, therefore, do we come to the conclusion that the use of mechanical pin fixation, even on simple fractures of the femur, will be thoroughly justified in military practice.

The same considerations do not apply to fractures of the tibia and fibula, both for the reason that they can get about in a long leg cast after

bone grafting or plating, and because many of the transverse fractures can be adequately controlled by a simple reduction and a snug plaster cast. On the other hand, fractures of these bones are particularly easy to treat by mechanical pin fixation and immediately thereafter they gain both knee and ankle motion. Consequently there is much to be said in favor of this treatment, even if the fracture is of a type that tends to displace. Fractures of the humerus are often so ill adapted to the simplest forms of conservative closed treatment, without interfering with ambulation, that they usually require less radical measures than the weight-bearing bones. For that reason we found less occasion to apply mechanical fixation in these cases than elsewhere. On the other hand, it offers an excellent means of treatment if the fracture is unmanageable and is especially useful if other injuries complicate the case. The forearm is perhaps the hardest location to treat with mechanical skeletal fixation, and possibly offers the fewest advantages. However in 2 of our cases, forearm fractures were complicated with dislocation of the head of the radius which had resisted several attempts at reduction in other hospitals (Fig. 5). By means of mechanical fixation each of these was reduced with anatomical repositioning. No other treatment could have been so successful. The use of Walsky apparatus on metacarpals is one of the most beneficial applications of mechanical fixation as it is being relatively simple. It obtains anatomical



Fig 7 Correction of a bad backward displacement of a fractured femur by the Haynes apparatus X ray shows slight distraction illustrating a preventable error Callus is forming but was delayed 20 weeks

reductions, at the same time freeing the hand for a remarkable degree of mobility (Fig 6) The use of the same apparatus on the jaw offers interesting possibilities, but really lies in a specialty outside the province of this paper It has already been discussed in the literature by its originators

#### ERRORS IN TECHNIQUE

Any new method of treatment should be studied from the standpoint of its harmful possibilities as well as its benefits In the case of mechanical skeletal fixation it seems certain that it will be subject to certain serious abuses From our experience, it can be said that such abuses will be due not to the mechanism itself, but to the errors of the surgeons using it Such errors may spring from ignorance or from incompetence They may be due to carelessness or impatience, or more especially to the inability of surgeons who are trained in manual manipulation to adapt their outlook to mechanical manipulations If such errors occur, it is vital that the surgeons should avoid blaming the principles of this treatment for failure due to their own faulty technique Our own experience has shown that four common dangers are present (1) It is important to insist upon the most rigid rules of asepsis governing the introduction of the pins, and the nursing staff as well as the surgeons must be strictly supervised The procedure appears so simple that carelessness may creep in (2) In applying the pins care must be exercised to see that they penetrate all the way through the opposite cortex Unless this is done,

full stabilization of the fracture cannot be gained, and in addition, the pins may move within the cortex and thereby cause irritation and invite infection (3) The danger of distracting a fracture must be continually guarded against, for even a slight amount of distraction will surely delay union This can be prevented by ending the mechanical reduction by a forced impaction, even though the maneuver may lose some of the anatomical perfection of the reduction itself This should be checked by roentgenogram rather than fluoroscope, and another roentgenogram should be taken in 3 weeks to determine whether any absorption has occurred at the fracture site If so, a second impaction should be carried out Figure 7 shows one of the fractures in our series in which a slight amount of distraction was allowed This roentgenogram shows good callus forming, but it was delayed 20 weeks, and at the time of the patient's transfer to a service hospital was still soft This was distinctly an avoidable error, though at the time the amount of distraction seemed slight enough to be overlooked (4) Lastly, in the postoperative care, it sometimes happens that the nursing staff or internes become overzealous in the matter of applying dressings over the pin wounds There is frequently a small amount of discharge at these sites, and it is important that the dressings should not be applied in a manner to interfere with or obstruct its outlet As a matter of fact, daily dressings are unnecessary and probably dangerous Anderson has suggested that the original dressings should

not be disturbed at all. It may prove advantageous, as Walters suggests, instead of using any dressings, to apply a light plaster casting round the limb in order to support the soft tissue. The protection and stabilization of the soft tissue is a major factor in eliminating the superficial discharge we have seen so often where muscles and skin pull against the pins.

#### END-RESULTS

Unfortunately no type of war surgery lends itself to accurate reports of end-results and least of all the results of fracture treatment. From the shortness of our observation, and from the transfer of patients and other interruptions in the observation period, we are unable to present any accurate picture of our findings and feel that it would be presumptuous to do so. The final test of mechanical fixation will have to come from a larger series of cases than ours, and from more controlled conditions. We can, however say that our impression is so completely favorable that a more widespread use of the method, under proper supervision can be enthusiastically recommended. Although too limited to be authoritative our cases tend to show that this method can be safely used in the presence of infection. Table IV illustrates that none of our clean cases became infected from the use of pins and that of all cases where infection was already present, only one formed sinus in the pin tract. This sinus was not serious and healed of itself within 3 months, but must be reported as an unfavorable complication.

The one case in which our own error delayed union for 20 weeks has already been noted. On the whole however union was speedier rather than delayed by the use of mechanical fixation. No instances of nonunion were produced.

#### CONCLUSIONS

1. Mechanical pin fixation offers very definite advantage in war surgery.
2. It has special value in the treatment of (a) selected fractures which tend to displace; (b) fractures complicated by severe shock; (c) fractures with long-standing debilitation from prolonged bed rest.
3. Under certain conditions, mechanical pin fixation may be recommended as a routine treatment for femoral fractures.
4. Possible errors and dangers in the use of mechanical fixation must be studied thoroughly.
5. The results of this series of cases so far as we have been able to observe them, justify more extensive use of mechanical skeletal fixation.

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# THE MECHANISM OF LABOR FOR TRANSVERSE POSITIONS OF THE VERTEX

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THE position of the fetal head at the pelvic brim and in the midpelvis, and the movements of engagement and descent and of internal rotation in the mechanism of labor, have produced considerable controversy during the past 200 years. The concept of the *normal* mechanism of labor almost universally accepted since the time of Baudelocque and Naegele, has been set forth in most obstetrical textbooks as occurring in the oblique diameters of the pelvic inlet. Physical science and technology of the 20th century have provided an excellent medium through the roentgen ray for visual perception of the labor mechanism *in vivo*. An important point has already been observed, namely, that the transverse positions of the fetal head (LOT and ROT) are most frequent, not only at the brim but also in midpelvis. Therefore, the mechanism of labor for these positions should be provided for.

Many methods have been developed by radiologists and obstetricians for roentgenographic study of the obstetrical patient. In our opinion, a complete examination should take into consideration the following points in approximate order of importance: (1) mechanism of labor, including position, lever action, internal rotation by visual perception in the stereoscope, (2) pelvic architecture by visual perception in the stereoscope, and by comparison of various diameters, (3) cephalopelvic size relationship visually in the stereoscope, (4) pelvimetry—stereoscopic and with isometric scales on frontal and lateral films, (5) cephalometry.

A high degree of attainment of this complete examination has been obtained with a *combined* radiographic technique which has been used since 1938. This consists of two frontal films of the inlet which are viewed in the stereoscope, as described by Caldwell, Moloy, and D'Esopo, and an isometric lateral film similar to that described by Thoms.

It has been of interest to learn that Hodges and Dipple (1940) recommended a similar approach as shown by the following statement:

"A reasonable simple and accurate procedure would be the following: (1) sagittal plane diameters measured from a single lateral roentgenogram by means of an isometric scale, (2) other pelvic diameters and fetal skull and skeleton studied in stereoscopic frontal films. Quantitative workup of these stereoscopic films accomplished by (a) plane geometric construction, or (b) by means of the stereoroentgenometer."

A preliminary report of the present study containing a small number of cases was made by Steele, Wing, and McLane in 1938, and consisted of data based on stereoscopic films. This represented experience over a 4 year period. Since that time, the *combined* stereoscopic and isometric lateral technique here referred to has been employed for another 4 year period and forms the basis for the present report. However, experience with the combined technique has shown the need for certain modifications which have been instituted as of January, 1942. A detailed description of the revised method of roentgenographic study has been published elsewhere by Steele and Javert.

## PRESENT STUDY

The present study comprises 1,300 patients at or near term, or in labor up to the completion of the first stage, and some postpartum patients. Elimination of positions other than the occiput and of the postpartum patients leaves 1,040 cases which form the basis for the present study. These cases have been divided into two groups: Group I—763 cases with occiput above or at the brim, Group II—277 cases with occiput in the midpelvis, either at, just above, or below the spines.

The incidence for the various positions in both groups are presented in Table I and Figures 1 and 2. In either group, the transverse positions account for 63.4 per cent and 62.8 per cent, respectively, confirming the results of Caldwell, Moloy and D'Esopo. As the head enters the midpelvis, the incidence of left occiput transverse (LOT) positions decreases, as does that for left occiput anterior (LOA), and right occiput transverse (ROT) and

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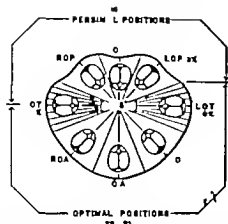


Fig. 1—Incidence of various positions of the occiput for above the pelvic brim—63 cases. Compare with Figure 2. The various positions are limited to an arc of 45 degrees instead of an arc of 90 degrees formerly employed for oblique positions. Posterior positions are regarded as *primæ* anterior as *primæ*.

right occiput posterior (ROP) positions increase while right occiput anterior (ROA) decrease. This change is probably due to the effect of dextrorotation of the uterus and may be one of the factors which cause the head to engage. Dextrorotation may also affect internal rotation, favoring left sided positions and opposing right sided positions as suggested by Figure 3 and the increased operative incidence for right sided positions.

The anterior and posterior oblique positions were observed with less frequency than is the pres-

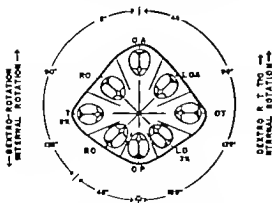


Fig. 2—Incidence of various positions of the occiput in the midpelvis—77 cases. Seen from below. Note how dextrorotation of the uterus affects the incidence of the various positions—dextrorotation occurs. Compare with Figure 1. Internal rotation is favored in left sided positions and is opposed in right sided positions.

TABLE I.—INCIDENCE FOR THE VARIOUS POSITIONS AT THE BRIM AND IN THE MIDPELVIS

	LOT	ROA	LOA	ROA	LOA	ROP	LOP	LOT	LOA	ROA	LOA
Group I*	38	4	1	1	1	1	1	1	1	1	1
Transverse	38	4	1	1	1	1	1	1	1	1	1
Group II†	33	7	5	5	5	5	5	5	5	5	5
Transverse	33	7	5	5	5	5	5	5	5	5	5
Grand total	71	11	6	6	6	6	6	6	6	6	6

\*Above or at brim.

†At, above or below symphysis.

ent clinic teaching. For example, in the midpelvis, posterior positions had a total incidence of only 16.5 per cent which is much less than the 27.1 per cent which Danforth obtained in his clinical study of 1,565 private patients.

For the purpose of classifying positions, the transverse positions, as well as the anterior and posterior positions, are limited to an arc of 45 degrees (22.5 degrees on either side of the transverse—a teroposterior and oblique diameter) as shown in Figure 1. In the past, an arc of 90 degrees has been employed for the oblique positions, and the direct anterior and posterior positions. The direct transverse positions have been ignored because of their supposed rarity.

Posterior parietal presentations occurred very frequently (75.3 per cent) at the brim of the pelvis, and were replaced by anterior parietal presentations as the head approached the cervix as shown in Table II. True synclitism, either at the brim or midpelvis, is such a transient occurrence as the head changes from posterior asynclitism to anterior asynclitism, that it was seldom seen, because the exposure of the film could not always coincide with its occurrence. Actually the majority of cases must experience momentary synclitism. The incidence of anterior parietal presentations in the midpelvis was 76.7 per cent which confirms the views of Naegle.

TABLE II.—SYNCLITISM AND ASYNCLITISM AT THE BRIM AND MIDPELVIS

	Group I		Group II		Grand Total
	No.	Per cent	No.	Per cent	
Posterior parietal presentation—posterior asynclitism	30	71	30	55	
Anterior parietal presentation—anterior asynclitism	36	7	113	76	
Synclitism	11		20		
Total	77		163		240

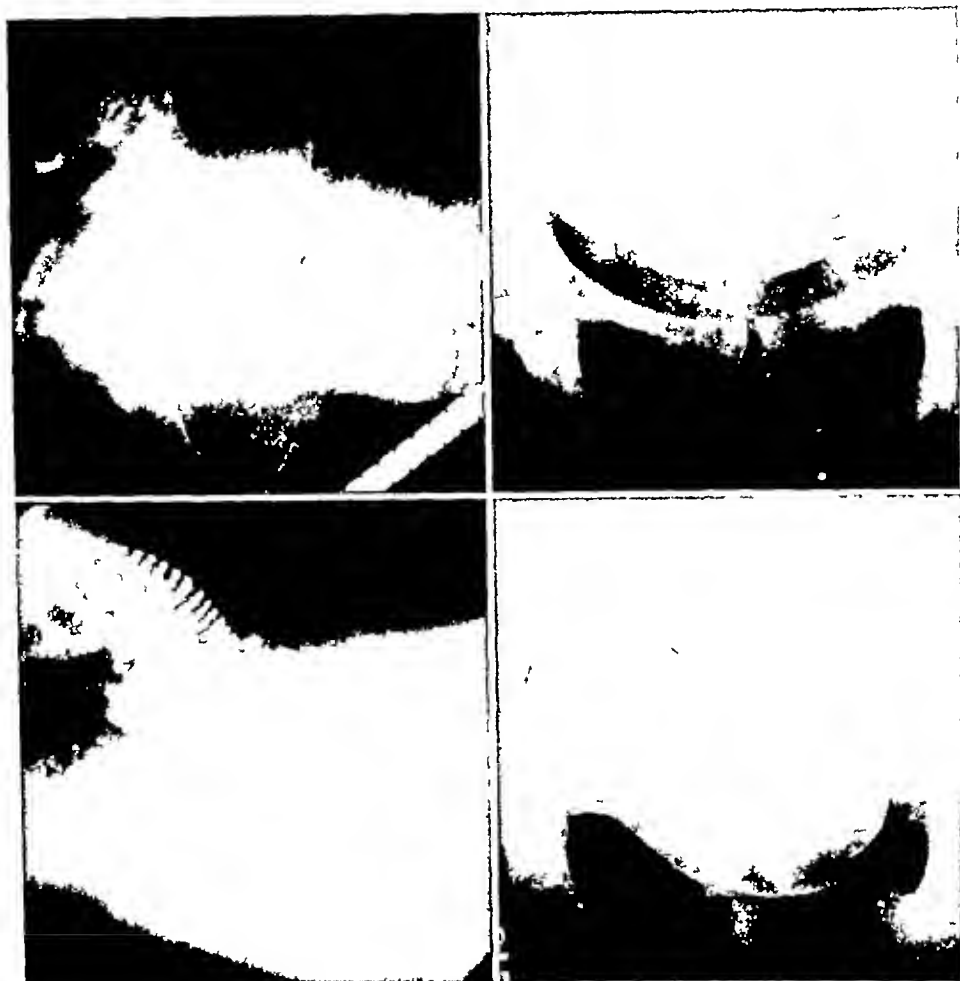


Fig 3 Frontal and lateral roentgenograms of head in left occiput transverse position at the brim and in the midpelvis. Note flexion of head in frontal films, and lateral flexion backward in the lateral films. Compare with diagrams in Figure 4.

#### THE MECHANISM OF LABOR FOR TRANSVERSE POSITIONS

The mechanism outlined has been evolved from observations made in the stereoscope and is usually associated with a normal pelvis. It will now be described for the left occiput transverse position (LOT).

At or near term, the head is found before engagement in the transverse position with the posterior parietal presenting over the fore pelvis (Litzmann's obliquity). The sagittal suture is in a horizontal plane above the symphysis pubis and slightly behind it. The relationship of the sagittal suture to the transverse diameter of the superior strait is one of parallelism or a diagonal direction

not exceeding  $22\frac{1}{2}$  degrees forward or backward as has been shown in Figure 1. Flexion is slight or absent. The fetal spine describes a gentle curve with convexity directed dorsally. Engagement is effected by lever actions which produce lateral flexion of the head backward, accompanied by ventral flexion of the fetal head as shown in Figures 3 and 4. The sagittal suture is now in the transverse diameter of the pelvis or much closer to it (synclitism). Simultaneously, descent begins and soon the posterior parietal presentation at the superior strait is replaced by an anterior parietal presentation in the midpelvis. The sagittal suture of the head has been shifted from a position over the fore pelvis to the region of the midpelvis and

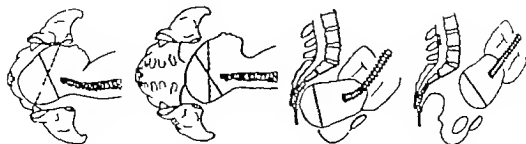


Fig. 4. Diagrams illustrating lever actions in transverse position. a, Ordinary flexion. Long occipitofrontal diameter is replaced by the shorter suboccipitobregmatic diameter. b, Diagram showing lateral flexion back and

forward. Posterior parietal presentation is an expansion of the biparietal diameter after which the anterior parietal presents. Compare these diagrams with the corresponding ones presented in Figure 3.

posterior pelvis. The lateral surface of the posterior parietal is now found to be nearly parallel to the anterior surface of the sacrum. Further

descent toward the sacrococcygeal platform occurs along a line which runs downward and backward and nearly parallel to the anterior sacral surface.

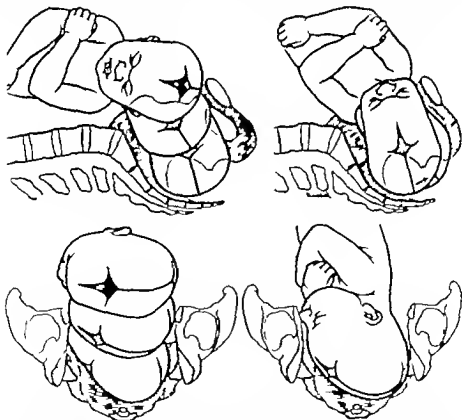


Fig. 5. The mechanism of labor for left occiput transverse position. Posterior parietal presentation of the brain (Litzmann's obliquity). Lever action produces lateral flexion of the head back and forward of the head on the chest. Anterior parietal presentation obtains after engagement. Lateral flexion forward places the posterior parietal against the left iliopectineal space and the occipitoparietal endence against the left iliopectineal space.

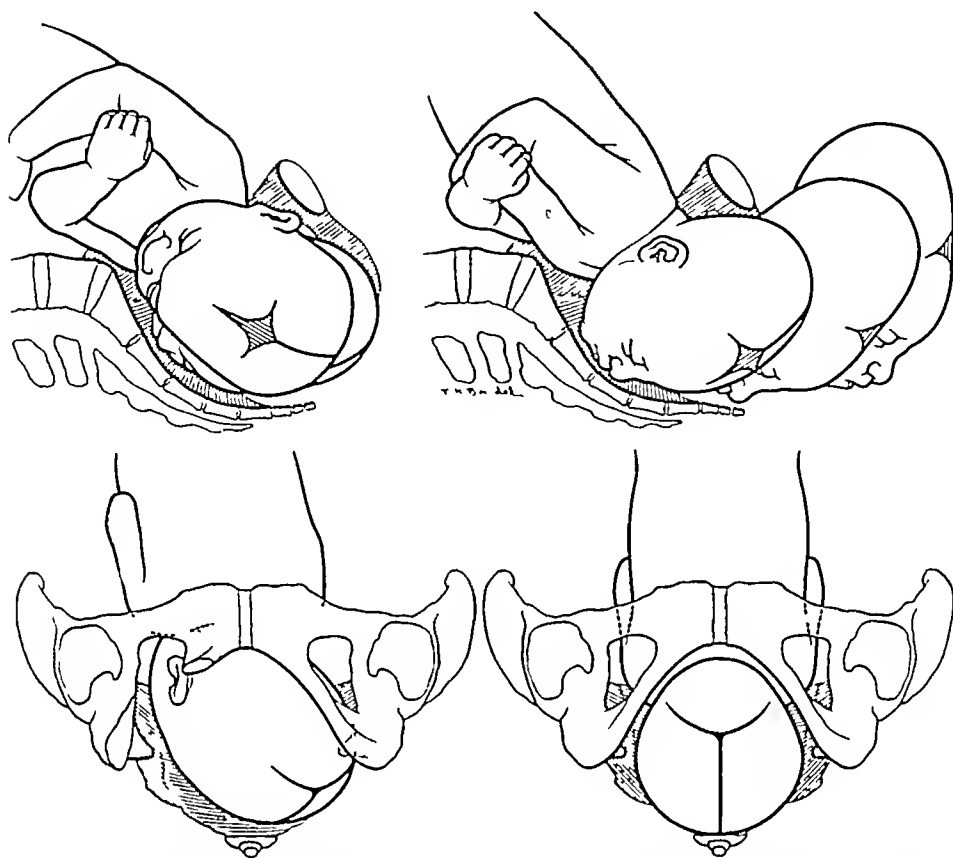


Fig 6 The mechanism of labor for left occiput transverse position. The occipitoparietal eminence traverses the inner curve of the ischiopubic ramus through an arc of 90 degrees producing internal rotation. The occiput is brought under the symphysis. Extension and expulsion follow. (See Figs 3, 4, 7, 8)

The head remains in the transverse position just above or at the ischial spines, with the anterior parietal now presenting, until the end of the first stage of labor. The fetal spine at this point may have straightened perceptibly and the flexion of the head has invariably increased (see Figs 4 and 5). Important lever actions are in motion. For

example, the acute ventral flexion of the fetal head on the chest results from the leverage exerted by the eccentric location of the fetal spine in relation to the long axis (occipitofrontal diameters) of the head. Posterior positions favor extension as shown in Figure 9.

At the beginning of the second stage of labor the fetal spine is found to be straight and flexion is acute. The picture is one of rigidity. The vertex assumes a position at or above the spines and continues to move downward and backward to the sacrococcygeal platform. Thereafter, lateral flexion forward occurs, and it precedes internal rotation. This movement in the mechanism has been checked repeatedly on vaginal and rectal examination. The left posterior parietal protuberance now impinges on the left ischial spine. The occiput rotates forward along the gentle curvature of the ischiopubic ramus (inclined plane

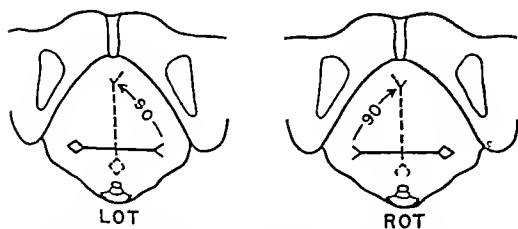


Fig 7 Internal rotation occurs through an arc of approximately 90 degrees in transverse positions

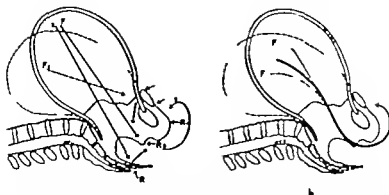


Fig. 8 a, Parallelgram of forces and the mechanism of labor. b, The resultant force produces Figure 6 curve. FF, directions of terine force during the first and second stages of labor. R, R<sub>a</sub>, resistance forces producing resultants which accomplish engagement, descent and internal rotation.

of Hodges) and internal rotation is produced through an arc of 90 degrees, as shown in Figures 6 and 7. Further descent occurs simultaneously during the rotation; the head remaining acutely flexed. Finally extension of the occiput usually begins at a low level (below the spines) and is followed by the movement of expulsion.

The above description can be modified to apply to the right occiput transverse position (ROT).

#### FURTHER OBSERVATIONS

The mechanism aforementioned is the same in all important essentials as that outlined by Meard and Varrier in 189. Their observations were made on frozen sections of women dying in various stages of labor. It has been striking and gratifying to confirm observations made on anatomical material 50 years ago by means of a recent cinematographic method of study which permits observation of the actual physiological process of labor *in vivo*.

The movement of posterior lateral flexion during engagement results from the force exerted by uterine contractions, and by intra-abdominal pressure and gravity being exerted in a downward and forward direction, plus the resistance offered by the anterior position of the lower uterine segment, the bladder and the symphysis. Thereafter, the uterine drive causes the head to descend rapidly downward and backward. Lateral flexion forward is the resultant of the uterine drive forcing the rounded parietal protuberance against the sloping surface of the lower sacrum. Internal rotation follows impingement of the parietal protuberance on the lumbal spine with the resultant following the inside curvature of the pelvic arch in an upward direction to the pubis. Extension is the resultant of the downward force of the uterine drive and abdominal muscles plus the upward and forward force exerted by the resistant pelvic arch as the occiput stems under the pubic arch. The movements are associated with a constant clamp

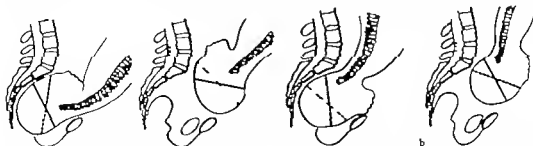


Fig. 9. Diagrams illustrating lever actions for anterior and posterior positions. a, Occiput anterior position. The long occipitofrontal diameter is replaced with the shorter suboccipitobregmatic diameter and flexion becomes acute.

b, Occiput posterior position. The shorter suboccipitobregmatic diameter is already available for engagement; flexion is not necessary. Head remains partly extended until expulsion or internal rotation produces.

in direction and exemplify the parallelogram of forces as indicated in Figure 8

Observations of Caldwell, Moloy, and D'Esopo have been confirmed with one important exception. They refer to lateral flexion forward in midpelvis as a mechanism encountered in the android type of pelvis, whereas our study shows that it may be regarded instead as an integral part of the most frequently encountered mechanism of internal rotation.

The lateral flexion of the head forward preceding internal rotation, is effected by the shunting action produced when the rounded vertex strikes the lower curve of the sacrum and fails to occur when the sacrum is long and straight, and the lateral bore of the pelvis is divergent. It is often under such circumstances that the head becomes arrested in the posterior pelvis—"transverse arrest." This exception tends to prove the rule with regard to lateral flexion forward in the midpelvis.

In view of the fact that the mechanism of labor here described is encountered in the majority of cases and is most frequently associated with a normal pattern of activity plus a spontaneous outcome, it should be included in the normal mechanism of labor. Heretofore, it has been considered pathological as the mechanism for flat pelvis by Farabeuf, Williams, and others. As has been shown historically elsewhere, many authorities recognized the transverse position *per se* prior to engagement but they preferred engagement in the oblique because of the sacral promontory. This objection no longer holds since the actual obstetrical conjugate lies in the plane of the ileopectineal lines as pointed out by Caldwell and Moloy and the point of intersection lies below the promontory in the majority of cases.

The mechanism of labor for direct occiput anterior position is *most optimal*, since internal rotation is not necessary, and normal flexion of the fetal head readily occurs because of normal lever action as shown in Figure 9. Conversely, direct occiput posterior positions are regarded as the least optimal, and therefore, *most pessimal*, because internal rotation must occur through an arc of 180 degrees, while lever actions promote extension of the head as shown in Figure 9.

The transverse position has good lever action, and internal rotation through an arc of only 90 degrees is required. For obliquely anterior positions this rotation is reduced to 45 degrees, but for obliquely posterior positions, it is increased to 135 degrees (see Fig. 2). This figure also indicates that the movement of internal rotation is enhanced by dextrorotation of the uterus in left

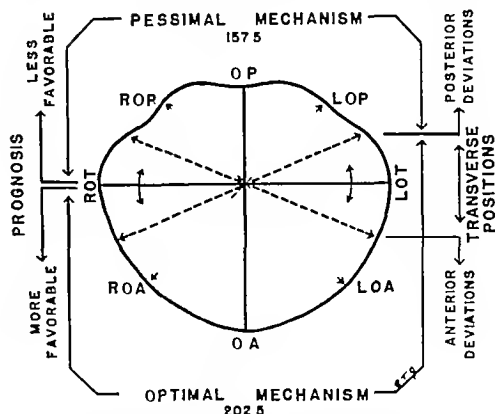


Fig. 10 Diagram showing how position and dextrorotation produces *optimal* and *pessimal* mechanisms of labor. Correct diagnosis of position is vital with regard to prognosis.

sided positions and hindered in right sided positions.

Analysis of the transverse position provides a satisfactory approach to the very complex problem of the mechanism of labor with its numerous interrelated factors and constantly shifting values. The high incidence of left occiput transverse and right occiput transverse positions (63 per cent) justifies this point of view. Variations from the transverse can then be designated as *anterior* and *posterior deviations* as shown in Figure 10. The transverse and anterior positions are normal and favorable and are therefore regarded as *optimal*. The posterior positions are less favorable as demonstrated by clinical experience, and are therefore *pessimal*. Prognosis can be ventured after evaluation of the various mechanical and dynamic factors.

At term, or in early labor, roentgen-ray images of the fetal skeleton reveal a spine with a gentle dorsal curvature. The head is in a neutral position, or very slightly flexed, with the posterior parietal usually presenting over the forepelvis, as shown in Figures 5 and 6. This picture is observed in the stereoscope on frontal films taken with the mother in a supine position. The lateral film, taken at the same time, but with the patient in an erect position, shows the fetal head to be wholly or partly engaged. A favorable cephalopelvic size relationship is a necessary requirement. It has always been striking that engagement could be accomplished with such ease. Having observed this occurrence hundreds of times, it has been concluded that dextrorotation of the uterus and an increase in muscular tension influence position

and engagement of the occiput, as shown by simply changing the maternal position. Clinical evaluation of disproportion can be carried out to advantage when the patient stands erect.

It is readily appreciated how left sided positions of the occiput can be brought forward more readily than right sided positions. Therefore the incidence of position at the brim and the midpelvis are different, due perhaps to the forces causing engagement. As shown in Figures 1 and 2 the incidences of right sided positions increase and left sided positions decrease as engagement occurs, and it is thought that dextrorotation is a responsible factor.

When cephalopelvic size relationship is less favorable, pelvic architecture becomes an important factor in determining position and may interfere with engagement. However many posterior positions occur when the pelvis is adequate and in these dextrorotation is perhaps an influencing factor. An appreciable percentage of posterior positions could probably be corrected with advantage early in labor.

Students and internes working with these concepts for the first time have found them to be of great value in their appreciation of the mechanisms of labor for the various positions.

#### SUMMARY

A roentgenographic study of 300 patients has been reported. A combined technique using an isometric lateral film and frontal stereoscopic films was employed.

It was soon apparent that this method of study provided a satisfactory means for classification of pelvic architecture and for visual perception of cephalopelvic size relationship. It also permitted study of the various positions at the brim and those in the midpelvis. The latter could be confirmed by rectal or vaginal examinations. Lever action and the mechanism of labor which is usually ignored by those employing other methods of roentgenography could be evaluated as well as pelvic and cephalometry.

Positions in the transverse oblique and anteroposterior diameters of the pelvic inlet were limited to 45 degrees on either side of the diameter concerned, in contradistinction to 90 degrees em-

ployed by authorities in the past. Engagement of the occiput in the transverse diameter occurred 63 per cent of the cases, while the remaining percentage engaged in the anteroposterior or the oblique diameters. The latter are regarded as anterior and posterior deviations from the transverse position.

A mechanism of labor for the transverse position based on visual perception in the stereoscope was evolved. It consists of the following movements: Transverse position and posterior rotation at the superior strait, lateral flexion backward, ordinary flexion, engagement and descent in the transverse diameter, anterior rotation in the midpelvis, lateral flexion forward, internal rotation, further descent, disengagement, extension and expulsion. This physiological order obtained from the roentgenogram received pathological confirmation from earlier investigators who studied frozen sections of cadavers.

Anterior and transverse engagements of the occiput result in normal and favorable mechanisms and are regarded as optimal, whereas posterior positions are presumed for stated reasons to bring lever actions and internal rotation. Dextrorotation of the uterus may facilitate internal rotation of the left sided positions and block rotation of right sided positions.

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# ASEPTIC GASTROINTESTINAL ANASTOMOSIS

## A One Clamp Method of Universal Application

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**T**HAT the problem of an ideal method of gastrointestinal anastomosis is unsolved is indicated by the succession of articles upon the subject describing new or modified instruments and techniques. At the outset we must admit that an absolutely aseptic technique is probably unattainable. Ligatures and clamps that crush the unopened bowel often force bacteria from the lumen through the intestinal wall, as shown by cultures made from the clamp or ligature used. Intestinal sutures may be contaminated by introduction to the submucosa (4) or even superficially when lymphoid follicles lie close to the serous coat. A bowel greatly distended from obstruction may have walls so thin as to perforate on introduction of even fine sutures. Nevertheless, we clamp and ligate the base of the appendix many times, and, although the laboratory often finds bacterial contamination through the appendiceal wall, the incidence of postoperative infection is no greater than after a similar number of clean abdominal sections in which the appendix or intestine is not crushed. If a purse-string suture is used in the cecum there is a small rise in wound infections but rarely with peritonitis. By a preliminary decompression of distended colon, the bowel thickens so that it may be sutured without perforation. By aseptic gastrointestinal anastomosis, therefore, we would refer to a practical or clinical asepsis associated with such slight bacterial contamination as to be insufficient to cause serious peritonitis or markedly to increase the incidence of suppuration in the abdominal wound. In contrast are the open and semiaseptic methods of anastomosis, procedures which may be done for peptic ulcer with such a low per cent of postoperative infection that aseptic methods, unless they provide at least as good technical results, are not so competitive. In conditions in which the hydrochloric acid in the stomach is low or absent, as with cancer, purulent and necrotic complications, obstruction with retained and contaminated contents and in operations upon the lower bowel an aseptic technique offers the possibility of marked reduction in mortality. Semiaseptic methods of anastomosis, as the method of Doyen (1897), that of Halsted (1891), of Gatch (1912),

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the knitting needle procedure of V. Pleth (1906), the de Petz stapler, and the pin and clamp method of Furniss (1934), while having advantages over the open method have an added risk.

An aseptic method should give good technical results. On this basis I would discard the various "bulkhead" methods introduced by Doyen and developed by the Halsted school and others. In the bulkhead method the divided ends of the bowel are closed by ligature and united end-to-end by suture, and then the double bulkhead is opened by dividing or withdrawing the ligatures or by cutting through the bulkhead. This method leaves inverted folds or partial diaphragms which may cause obstructive symptoms, is limited largely to an end-to-end type of anastomosis of the intestine and is inferior to methods of anastomosis by suturing over clamps.

Suture of the bowel ends or sides over straight crushing clamps, which prevent leakage and facilitate suturing, was introduced by O'Hara in 1900 after he had noted the defects of the circular clamp introduced by his chief, Laplace. The O'Hara clamps had the advantage of narrow calibrated blades with one flat side, tongue, and grooved crushing surfaces, and pin fittings so that the two forceps, each holding an end or side of intestine, could be apposed and held in alinement by an additional small clamp. With these forceps end-to-end, end-to-side, or side-to-side, anastomosis was feasible. The O'Hara forceps, adequate for the suture of dog's intestine, with which he largely experimented, had blades too light and narrow to hold securely the thicker human bowel, and a number of larger forceps incorporating O'Hara's principles have since been devised. By using narrow blades which, however, are rather insecure, the amount of bowel inverted in the anastomosis is reduced. To prevent the tendency of the viscus to slip from the narrow blades it may be crushed previously or simultaneously (Rostowzew, 1906), or uncrushed edges may be left projecting beyond the forceps, while the tips may be held in apposition by ferrules or other devices.

Rostowzew, using in part the O'Hara plan, devised heavy crushing clamps holding slender clamp blades in the jaws (1907), while Parker and Kerr in 1908 used clamps for the introduction of



temporary basting stitches which inverted and held the ends of the bowel closed until definitive anastomosing sutures were in place. This additional step is of advantage when the clamp does not hold the bowel securely or does not permit desired mobility.

Moszkowicz (10) in 1908, following Rostowzew also devised mobile clamps by clumbrating the handles and used added devices (pliers and ferrules) to compress and to lock the blades together changes which later were improved upon by deMartel, Cope Stone (1) and others. In 1909 Moszkowicz (11) combined in one the two clamps previously used, devising a three bladed clamp with three handles, which was greatly improved and popularized by Rankin in 1908 by incorporating the excellent mechanical principles of the two-bladed Payr clamp. The tongue and grooved blades, to which multiplied levers carry great increase of any force applied to the handles, give the Payr type of clamp a security in crushing and holding thick intestinal or gastric wall not possessed by other clamps with cross-hatched blades or less leverage.

The object of this paper however is not to introduce a new clamp for gastrointestinal anastomosis, but to demonstrate what apparently has been largely overlooked that nearly any type of anastomosis for which clamps are used can be done rather better aseptically and with both a single clamp. A single clamp with blades broad enough to hold well, as a rule will have less metal to sew over than two narrow less secure clamps or a three bladed clamp. Less bowel or stomach therefore, may be turned in to form an objectionable partial diaphragm and constrict the lumen when a single clamp is used. A single clamp is simpler to apply and to disengage and with less manipulation there may be less contamination. With a single bladed clamp a partial or complete gastrectomy a partial esophagectomy or gastroesophagectomy an anterior or posterior gastroenterostomy an end-to-end side-to-side end-to-side or partial oblique enterectomy may be done. For most purposes I consider the small Payr clamps superior but an Ochser or Kocher hemostat, Martzloff Bunget Wangensteen clamp, the Stone clamp the deMartel-Cope clamp or other similar instrument may be used. For convenient work in the depths of the abdomen clamps without handles are desirable. With number of such clamps of different lengths, complicated and multiple resections of the stomach and intestine may be carried out without soiling. Clamps render apparatus for mechanical semiaseptic suturing quite unnecessary.

There are in the literature a number of references to the use of single clamps for anastomosis. Rostowzew used the slender blades previously mentioned held in the jaws of his powerful crushing enterotribe and interrupted sutures. Perce considered a single clamp applicable only when the intestine was small and the wall thin and transparent. He inserted and tied the clamp before withdrawal of the clamp. When the caliber of the intestine was normal or large Percevel added coprostatic clamps with right angled blades and a row of right angled invaginations. A single clamp method with the bowel ends reversed in the clamp is described by Samuels, and the use of a pile clamp with or without a preventive basting stitch, by Brenner.

The aseptic single clamp methods to be described illustrate adaptations of many procedures long used in intestinal surgery to a single principle for safer and more convenient gastrointestinal resections.

#### RESECTION AND END-TO-END ANASTOMOSIS OF INTESTINE (FIG. 1)

The loop of intestine to be removed with the attached mesentery is liberated and the arms of the loop at the lines of proposed resection are imposed by four gray sutures (Fig. 1a) or two other visceral forceps to maintain proper alignment. While traction is used to spread the exposed loops two crushing clamps are applied about 5 millimeters apart. Each clamp includes both arms of the intestinal loop in its grasp. The loop of liberated bowel is cut off by cautery between the two clamps (Fig. 1b). The ends of bowel to be anastomosed now remain allowed in the grasp of a single clamp. This clamp is turned over and two posterior rows of interrupted or continuous sutures are introduced (Fig. 1c). The clamp then is rotated back to its first position, thus exposing the anterior surface of the bowel and a continuous

Fig. 1. Aseptic intestinal anastomosis with single clamp. a, Arms of long or short loops of bowel to be resected superimposed and aligned by traction sutures. Broken line indicates line of section. b, Arms of loop distal to clamped, being divided by cautery. c, Resected loop turned over with insertion of first posterior row of anastomotic second row to follow. d, Clamp turned back, thus exposing anterior face of bowel. An other continuous suture is introduced over or under clamp. Clamp spread, and second row of anterior continuous suture is tightened. (Second row of anterior sutures being introduced. G, Double sutured resection illustrated by removal of short loop of attached ileum with section of colon. The loop of ileum folded together, divided by cautery between distal placed clamps and then, with the resected mesentery clamped by row of sutures, is applied behind and over the clamp as c, d, e.

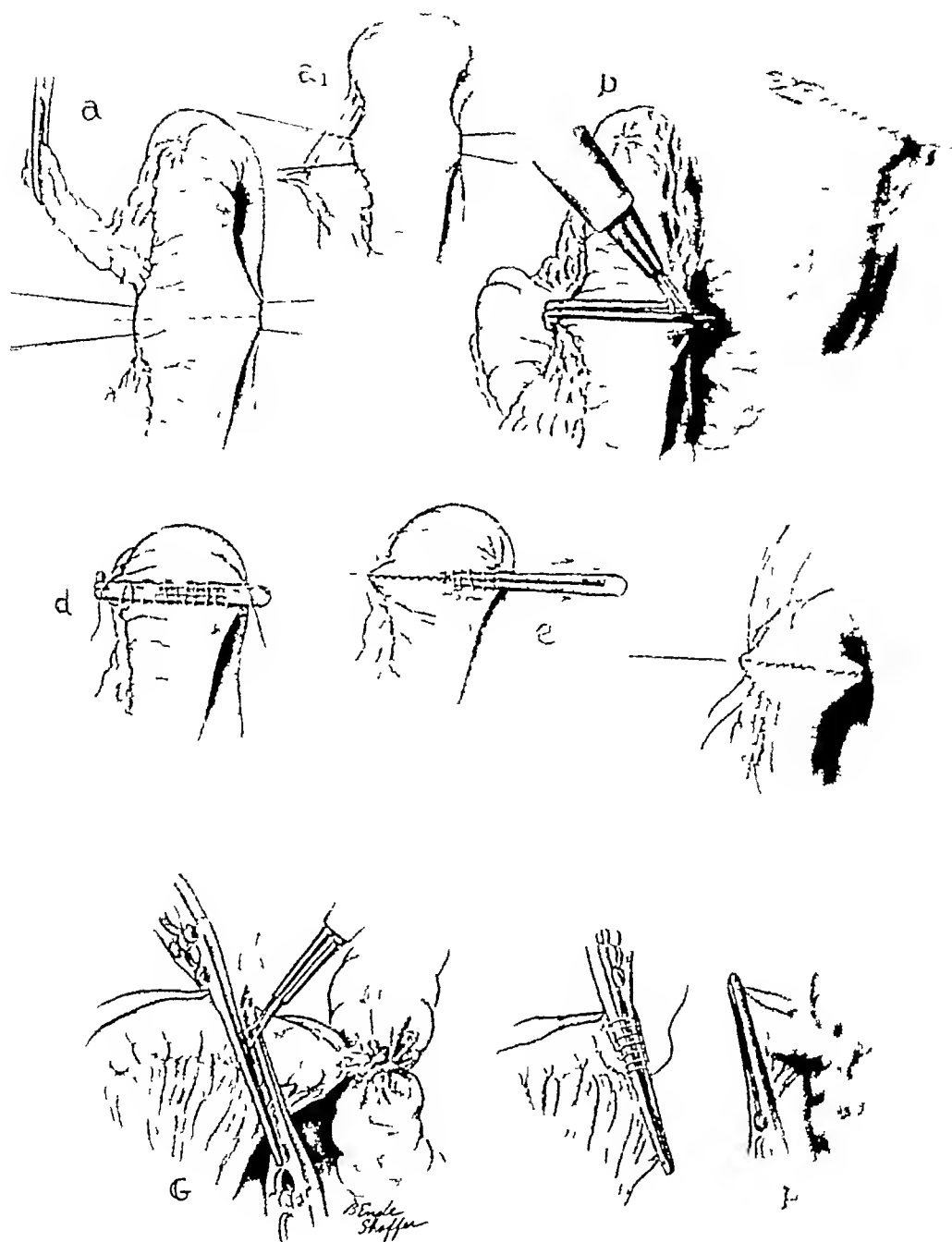


Fig 1  
(Legend on opposite page)

Cushing suture is applied over the clamp (Fig. d). While traction is made upon the ends of this anterior continuous suture the clamp is withdrawn, thus inverting the mucous edges into the lumen of the bowel and completing the closure without leakage (Fig. e). The ends of the anterior suture are tied to contiguous ends of the inner posterior suture. One or two additional anterior rows of continuous or interrupted anterior sutures are inserted as required (Fig. f). The lumen is established by invaginating the adjacent intestinal wall with the thumb and finger.

The removal of a small segment of bowel which has been traumatized or invaded by inflammatory or malignant process may be carried out very expeditiously by the oblique single clamp method. The affected loop is folded together and the clamp is applied obliquely across the base of the segment of intestine and mesentery to be removed (Fig. g). A second clamp is applied a few millimeters distal to the first and the segment is cut off between the clamps with a cautery. The segment to be removed then may remain clamped and attached to the primary malignant or inflammatory area in connection with which it can be removed later. Traction and approximating sutures or forceps often are unnecessary for this simple operation. After removal of the segment of bowel and omentum, the anastomosis is completed by the introduction of rows of posterior and anterior sutures similar to those described for an end-to-end anastomosis. The anterior inverting suture is carried in advancing loops along the edges of the omentum thus simultaneously closing the gap and treating hemorrhage.

This type of resection is a quick and convenient way to deal with gunshot wounds and other injuries of the intestine, fistulous areas as well as localized tuberculous and malignant implantations. The smallest Payr clamp is preferred and is used to crush simultaneously both the bowel and the folded edge of the mesentery. I have resected thus over 30 centimeters of small intestine without an individual ligature in the mesentery. Care should be taken that the mesenteric edges of the bowel are enfolded properly by suture.

#### ILEOCOLECTOMY WITH END-TO-END ANASTOMOSIS (FIG. 2)

The distal part of the ileum, the cecum, appendix ascending and if desired, part of the transverse colon are liberated for removal. By means of four gu. sutures or visceral forceps the ileum is spread obliquely over the transverse colon and, while traction is used to align the superimposed segments of bowel, two clamps are applied about

5 millimeters apart across both colon and ileum (Fig. 2A). The arms of the loop then are drawn between the clamps by cautery (Fig. 2C). The clamps should crush the ileum obliquely from the mesentery away from the lesion, the transverse colon transversely in such fashion that the opening of the ileum will have the same diameter as that of the transverse colon. The ends of the ascending and transverse colon to be united now are exposed in the grasp of a single preferably Payr clamp. The clamp is turned over and the posterior row of interrupted or continuous sutures are introduced. This may be done before the loop of bowel has been removed as shown in Figure 2B, or preferably after the division by cautery shown in Figure 2C. The clamp then is removed, thus exposing the anterior surfaces of the colon and ileum and a continuous anterior Cushing suture is introduced over the clamp as shown in Figure 2D. The clamp is removed as this suture is tightened, thus inverting and approximating the anterior edges of intestine and the ends of the suture are tied to corresponding ends from the first posterior row. One or two additional rows of interrupted or continuous sutures are inserted anteriorly as shown in Figure 2E. Before any sutures are introduced all fat and omentous tissue are dissected carefully from the surfaces to be united and new arterial circulation up to the margins of the clamp is proved. As with all these anastomoses, immediately following the insertion of sutures, the lumen of the bowel is re-established by pressure between the thumb and finger. We consider this method preferable to a side-to-side anastomosis.

#### SIDE-TO-SIDE INTESTINAL ANASTOMOSIS

The segments of bowel to be united are aligned and two rows of posterior sutures are introduced thus uniting the anterior face of the upper segment and the posterior face of that superimposed below the antimesenteric borders. These posterior sutures also may be introduced after the application of the clamp. The antimesenteric borders of the contiguous loops of bowel, held together by visceral forceps or sutures, are elevated and the two longitudinal folds of bowel identified and crushed together by a clamp which should include the mucous lining of each fold. The folds of bowel projecting above the clamp now are burned off to form continuous longitudinal openings in each loop. An anterior continuous Cushing suture is applied over the clamp which is tightened as the clamp is withdrawn and the ends of the suture are tied to adjacent ends from a posterior suture line. Such additional anterior row or rows of interrupted or continuous



Fig 2 Ileocolic anastomosis A, The loop of ileum and colon to be removed has been liberated, and under traction a clamp has been applied obliquely to the ileum, transversely to the underlying colon. On the ileum the clamp inclines proximally to the antimesenteric border. B, The clamp has been rotated and the first row of posterior sutures inserted.

A second row follows. C, A protective distal clamp is applied and the loop amputated by cautery. D, The anterior continuous Cushing suture over the clamp inserted. E, With withdrawal of the clamp the Cushing suture has been tightened and an additional anterior row of sutures is being introduced.

sutures as seem desirable are introduced and the opening between the two loops is established by digital manipulation.

#### END-TO-SIDE ANASTOMOSIS USING A SINGLE CLAMP

For clarity the procedure will be described as an anastomosis between the end of the ileum and

the side of the colon. The ileum having been divided by cautery between clamps, the proximal end, closed by one of the clamps, is placed across the colon so that the clamped end approximates the antimesenteric border of the colon. The posterior surface of the ileum is united to the anterior surface of the colon by two rows of sutures run-

ning parallel with the border of the colon. A continuous fold of the antimesenteric border of the colon is raised by a row of viscera forceps over a length corresponding to the width of the ileum. A clamp is applied to this fold of colon below the viscera forceps, including the clamped end of the ileum. The end of the ileum with its clamp and the projecting fold of colon above the clamp are burned off by cautery. This leaves a side opening of colon and a terminal opening of ileum in juxtaposition. A continuous Cushing suture is applied over the single clamp which is tightened as the clamp is withdrawn and the ends are tied to appropriate ends of the upper posterior row of sutures. One or two additional rows of sutures are inserted anteriorly between the colon and ileum to reinforce the union.

For multiple resections it is desirable to have a number of small short clamps available to prevent leakage and infection and to aid the later approximation in a single clamp. Just before the provisional occluding clamps are burned off with the intestinal ends. This greatly facilitates complicated forms of anastomosis, as in cases in which multiple sections of bowel or bowel and stomach must be removed. To facilitate these operations I have made a number of short and long bladed clamps resembling the Stone clamp but having the locking device of the deBartlett type. By tapering and streamlining the blades of the clamp it may be removed easily from under the existing continuous Cushing suture. The Stone clamping forceps is not powerful enough to close such a clamp upon the distension of even thick esophagus, but sufficient pressure may be applied to the blades by Payr clamp or strong pliers. In the introduction, removal, and fixation of the clamp in the depths of the abdomen or thorax, removable holding device which will not interfere with opening or closing the clamp is desirable, especially during the introduction of sutures (Fig. 75). In using long bladed long gastric clamps additional pressure near the middle of the blades, where they tend to spring apart under strain, may be necessary and is supplied by a yoke with screw pressure (Fig. 76).

#### MULTIPLE INTESTINAL RESECTIONS WITH A SINGLE CLAMP

For clarity we will consider that a cancer of the transverse colon has fixed the underlying jejunum. A pair of short clamps are applied to the colon well to the left of the lesion and similarly to the jejunum, and the colon and jejunum are divided between the clamps by cautery. Similar pairs of short clamps are applied to the colon and jejunum well to the right of the lesion, and the colon and jejunum are separately divided by cautery between these clamps. The diseased attached segments of colon and jejunum are liberated and removed together. This leaves a proximal and distal segment of colon, each end aseptic and protected by a clamp and a proximal and distal end of jejunum, each end also closed by a clamp. The two jejunal clamps then are apposed, the under-

lying segments are crushed together by a single clamp, above which the two jejunal ends with their attached clamps are burned off. This leaves the two ends of jejunum superimposed in the grasp of a single clamp and the anastomosis is completed with rows of posterior and anterior sutures as described for an end-to-end intestinal anastomosis with a single clamp. A similar procedure then is used to unite the proximal and the distal clamped ends of the colon. This method, with the temporary application of multiple short clamps, also is used when it is not feasible at first to liberate a loop of bowel to be excised.

#### ABDOMINOPERINEAL PROCTO-COLORECTOMY WITH PERINEAL ANUS AND THE FORMATION OF PELVIC DIAPHRAGM

The segment of rectosigmoid to be removed is liberated with its attached mesentery to the pelvic floor divided well above and also well below the lesion by cautery between short clamps, and removed. The proximal sigmoid and, if necessary, the adjacent descending colon is sufficiently liberated that the viable end will reach through the pelvic floor or about 5 inches below the posterior pelvic brim. The proximal and distal clamps each covered with stockinet are laid against the floor of the pelvis. A pelvic diaphragm of liberated peritoneum, including that from the bladder now is formed around the segment of sigmoid in the pelvis and the abdomen is closed. Through an incision from the posterior border of the anus along the side of the coccyx, the pelvis is entered and the stockinet, attached clamps, and bowel segments are withdrawn. The anal segment, having been thoroughly cleaned perianth and packed with antiseptic gauze, is resected and split posteriorly with removal of its clamp and the clamped end of the sigmoid is laid in the anal gutter thus formed. A curved, perforated drain is left in the hollow of the sacrum sutures introduced, dressings applied, the sigmoid clamp removed, and a rectal tube is tied in the sigmoid. This procedure obviates the difficulty of forming a pelvic diaphragm when a pull-through type of proctosigmoidectomy is done.

Occasionally with perforated carcinoma and associated abscess, it is possible to end today by an en masse resection. Mrs. R., rather obese patient, had developed large abscess of the left abdominal wall 7 months before admission. This had been drained through long incision which had healed after 4 months. On admission it was evident that residual abscess still existed in the fatty dissection all wide elliptical incision as made last time, which was found attached to large cancer involving the splenic flexure and adjacent transverse and descending colon. A very large loop of colon was liberated with its attached abdominal wall, and the anus of the loop freed



Fig 3 Billroth I Partial gastrectomy A, The part of stomach to be removed has been liberated, the duodenum divided between clamps B, The duodenum is stretched across the posterior surface of the stomach and the outer row and a part of the inner row of posterior sutures introduced C, The stomach and attached duodenum are doubly clamped together and divided by cautery distal to the suture lines Usually, to conserve duodenum, the protective

distal clamp is applied to the stomach alone D, An anterior continuous Cushing suture is being inserted, in part between the anterior surface of the stomach and duodenum, in part between the anterior and posterior surfaces of the stomach E, The Cushing suture is tightened as the clamp is withdrawn F An additional row of inverting anterior sutures is applied between stomach and duodenum, and over projecting ends of stomach

of the proximal transverse colon and the proximal sigmoid were apposed and divided by cautery between clamps An end-to-end anastomosis was carried out over the single remaining clamp A complementary cecostomy was done The patient recovered without wound abscess

#### SUBTOTAL GASTRECTOMY WITH A SINGLE CLAMP

Subtotal gastrectomy with a single clamp may be done after the Billroth I, Reichel-Pólya antecolic, retrocolic, or the Hoffmeister-Finsterer plan

*Billroth I, partial gastrectomy* (Fig 3) The portion of stomach to be removed is liberated in the usual manner (Fig 3A), the duodenum divided between clamps by cautery and the lower part of the stomach turned out of the wound over the left thoracic wall, exposing its posterior surface The duodenum is mobilized by the Kocher division of the hepatoduodenal ligament The posterior sur-

face of the clamped duodenum is stretched along the line of proposed anastomosis on the posterior wall of the stomach by two transverse rows of posterior sutures A narrow Payr or other reliable clamp is applied across the stomach and duodenum above the suture lines and below the duodenal clamp If the clamp is too short to reach across the stomach a second may be applied from the opposite side The combined stomach and duodenum now are divided together by cautery between the clamps (Fig 3C) This removes the end of the duodenum with its clamp Usually the duodenal clamp is placed between the other two clamps instead of as shown in the figure The edges of both stomach and duodenum now are approximated in the jaws of a single clamp The anterior surfaces of the stomach and duodenum

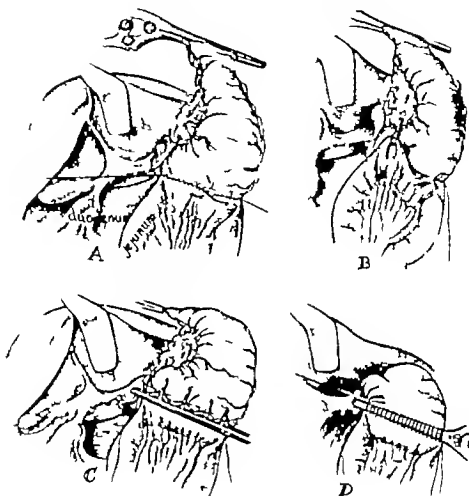


FIG. 4

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are tied over the clamp with a continuous Cushing suture. If the distance is long it may be divided between two continuous Cushing sutures. The suture also unites and inverts the anterior and posterior edges of the stomach except where the stomach is covered by duodenum (Fig. 3D). This continuous suture is tightened as the clamp is withdrawn (Fig. 3E), fixing and inverting the end of the duodenum between the edges of the stomach. The ends of the continuous suture are tied to adjacent end from the posterior row. An additional one or two rows of interrupted or continuous anterior sutures are introduced as shown in Figure 3F. The tomo is opened by manipulation

*Resection of the stomach and small intestine (Fig. 4).* The desired portion of stomach is liberated, the duodenum is divided by cutters between clamps, and the stomach is reflected out of the abdomen. The distal end of the duodenum is closed over the clamp, by means of a continuous Cushing suture, which is tightened as the clamp is withdrawn, and the closure is reinforced by one or two rows of additional sutures which further invert the edges. A loop of jejunum about one-half meter below the ligament of Treitz is brought in front of the colon and its posterior surface fastened across the posterior surface of the stomach with two rows of interrupted or con-

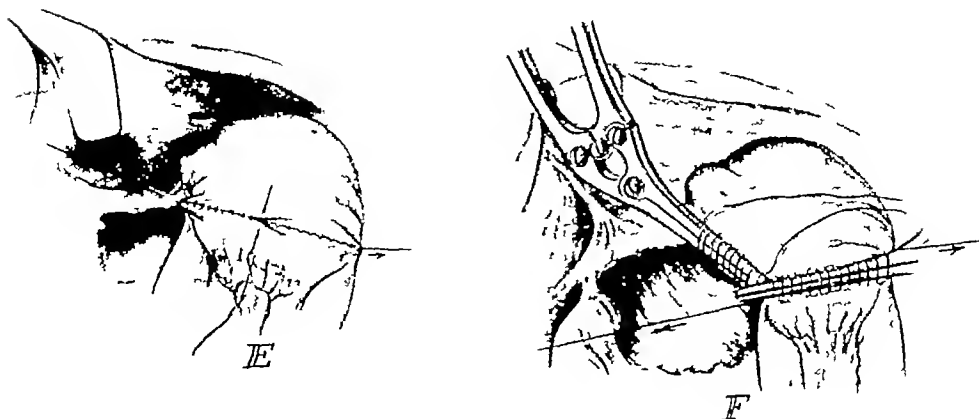


Fig 4 Antecolic or retrocolic Reichel Pólya partial gastrectomy A, The stomach liberated, the duodenum divided between clamps and the lower end of the stomach turned out of the wound. The posterior surface of a loop of jejunum is being united across the posterior surface of the stomach with two rows of sutures B, An antimesenteric fold of jejunum is raised against the posterior surface of the stomach by forceps or sutures C, A clamp is applied across the stomach and the antimesenteric fold of jejunum distal to the suture lines D, Divided line indicates position of protective clamp E, The stomach has been divided between clamps and the antimesenteric border of the jejunum burned off by cautery, leaving the open edge of jejunum and end of stomach in the grasp of one clamp F, The stomach has been divided between clamps and the antimesenteric border of the jejunum burned off by cautery, leaving the open edge of jejunum and end of stomach in the grasp of one clamp An anterior Cushing suture has been applied over the clamp E, The anterior continuous suture has been tightened as the clamp was withdrawn, and tied A second row of reinforcing sutures is being introduced When there has been a previous gastroenterostomy or gastric resection the two clamped and divided ends of jejunum may be united side to side to the end of stomach using a single clamp, after the plan of the Billroth I (Fig 3), except that a double barreled end to end jejunal juncture is made with the end of the stomach F, Arrangement of the clamps for a Hoffmeister Finsterer modification The stomach has been resected The posterior sutures between the stomach and jejunum have been placed An anterior Cushing suture has been inserted over each clamp, each one to be tightened as the clamp is withdrawn The operation to be completed by an additional row of sutures

ous sutures (Fig 4A) A fold of the antimesenteric edge of the jejunum is raised by viscera forceps or sutures across the line of proposed division of the stomach, as shown in Figure 4B A single clamp is applied across the stomach and the antimesenteric edge of the jejunum below the line of visceral forceps It is important that the mucous lining of the jejunum projects above this clamp when it is closed (Fig 4C) A distal protecting clamp is applied across the stomach, and the stomach is divided between the clamps and projecting fold of jejunum burned off by cautery An anterior continuous Cushing suture is applied over the clamp between the anterior surface of the stomach and the anterior surface of the jejunum (Fig 4D), and the clamp is withdrawn as this suture is tightened The ends of this suture are tied to ends of the upper posterior row of sutures and an additional row of anterior interrupted or continuous reinforcing sutures is introduced (Fig 4E) Obviously a shorter stoma may be formed by including a shorter fold of jejunum in the single clamp, or a double barreled gastrojejunostomy by including a complete loop of jejunum Figure 4F illustrates

the technique for the Hoffmeister-Finsterer partial gastrectomy, using two clamps and two continuous inverting Cushing sutures In any case a sufficient fold of jejunum should be brought through the clamp to include the mucous lining, otherwise, an open stoma will not be formed

For a retrocolic anastomosis the loop of jejunum is brought through an opening in the transverse mesocolon and the anastomosis is then made as with the anticolic method At the completion of the retrocolic anastomosis the stomach along the line of anastomosis is sutured to the edges of the opening in the transverse mesocolon

#### GASTROJEJUNOCOLIC RESECTION FOR GASTROJEJUNOCOLIC FISTULA

The colon and jejunum are doubly clamped separately on each side of the fistula and are divided between the clamps by cautery If the original peptic ulcer has healed it now may be feasible to remove, between clamps by cautery, the segment of stomach containing the stoma, with the attached clamped segments of colon and jejunum



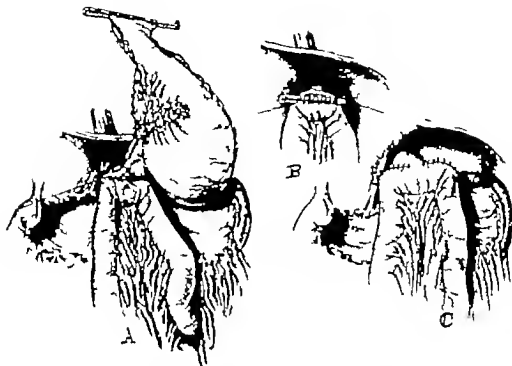


Fig. 5. Total gastrectomy. A, The duodenum is divided between clamps and the distal end closed by suture. The stomach, liberated, side of the lesser, is turned out upon the chest. The esophagus has been partly liberated and withdrawn from the diaphragm. The row of sutures are being introduced between the posterior wall of the esophagus and the posterior wall of the loop of jejunum. With completion of the posterior row of sutures, a clamp will be applied across the esophagus and an antimesenteric fold of jejunum (similar to Fig. 4, C, D) and the esophagus

divided between clamps and the antimesenteric fold of jejunum burned off by cautery. B, The open end of the esophagus and open side of the jejunum are compressed by the single transverse clamp. A continuous Cushing suture is being applied over the clamp. C, The Cushing suture has been tightened as the clamp is withdrawn, and an additional row of sutures applied to reinforce the sutured edges and to support the antrum of the jejunum in the diaphragm. A flap from the under surface of the diaphragm may be added for reinforcement.

The stomach then is closed over the remaining clamp as in terminal closure of the duodenum. The two jejunal clamps are apposed, the ends of jejunum aligned and clamped together by a third clamp and the projecting clamped ends of jejunum are burned off by cautery. This leaves in a single clamp the ends of the resected jejunum in position for a aseptic end-to-end anastomosis, which is then followed by a similar aseptic end-to-end anastomosis for the resected transverse colon. The gaps—the transverse mesocolon and in the jejunal mesocolon—are closed by suture and a complementary appendicostomy or oecostomy is done. In most cases instead of the segmental resection of the stomach described it is better to do a Polya or Hofmeister partial gastrectomy. In

this case, after liberation of the stomach and division of the colon and jejunum between clamps, the liberated stomach with the attached clamped remnants of small and large intestine is turned out of the abdomen. The retained jejunum and colon are united end-to-end over a single clamp as previously described and a lower segment of intact jejunum used for the gastrojejunal anastomosis. If the proximal arm of the existing gastrojejunostomy is long enough, which is not usual after a short loop posterior gastrojejunostomy, double barreled end-to-end anastomosis between the two ends of the jejunum and the end of the stomach may be done following the one clamp technique, thus eliminating the jejunal side-to-end anastomosis.

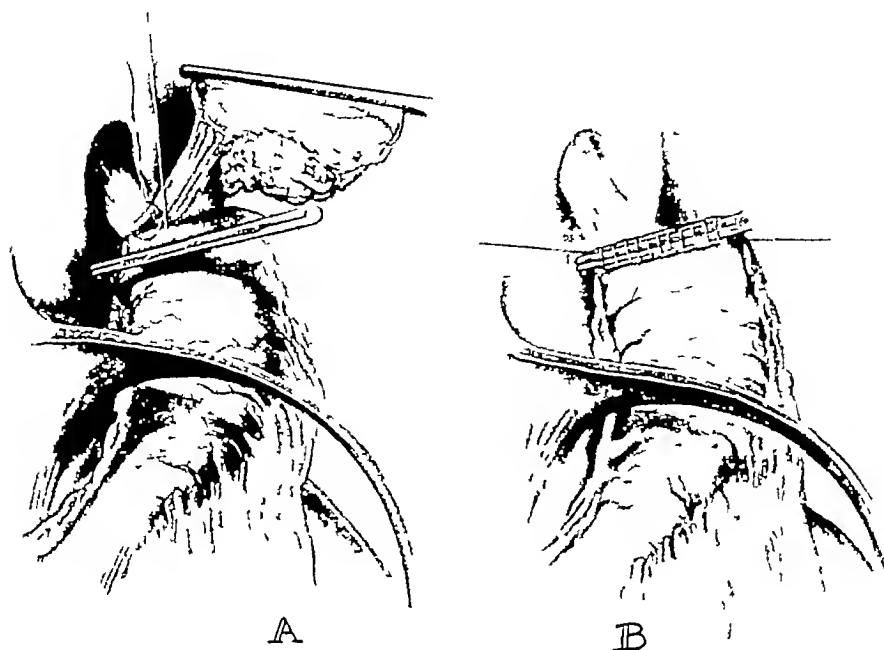


Fig 6 Transthoracic resection of the cardiac end of stomach and lower esophagus A, Through a thoracic incision the stomach has been liberated, brought into the chest and divided by cautery between clamps well below the tumor. The posterior surface of the distal end of the stomach is being united to the posterior surface of the esophagus with two rows of sutures. Two clamps are to be applied across both stomach and esophagus anterior to the suture lines and the stomach and esophagus divided by cautery between these clamps. B, This leaves the ends of the stomach and esophagus in the grasp of a single clamp. An anterior Cushing suture has been inserted, which is to be tightened as the clamp is withdrawn. C, Additional reinforcing and supporting sutures are introduced.

In one patient in whom the fistula was small and running directly from the stomach into the transverse colon the colon was closed by inverting sutures without resection. The arms of the jejunal loop were liberated through the transverse mesocolon, each arm was divided between clamps and the liberated portion of stomach with the two clamped arms of jejunum attached turned out of the wound upon the chest. A single clamp was applied under the two clamps closing the ends of the retained jejunum and the jejunal ends with their clamps were burned off thus leaving the two aseptic ends of jejunum approximated in the single clamp in position for an end to end aseptic anastomosis. After this anastomosis had been completed a more distal segment of the jejunum was used for an antecolic Ilya type of gastric resection. The patient had an uncomplicated convalescence.

In bloc resection of the stomach, transverse colon superior layers of the pancreas and associated abscess for per



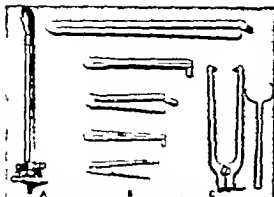


Figure 7. A. Clamp holder to facilitate placement and manipulation of clamps in depths of wound. B. Modifications of deMartel and Stone clamp, and for septic gastro-intestinal anastomosis. C. Compression yoke with removable key occasionally desirable to increase compression of the longer gastric clamps, and especially for lateral resections of stomach. One the locking dog cannot be used.

**Isolated gastric carcinoma.** A woman of 60 years had left lobe about 5 centimeters in diameter surrounded by adherent stomach, pancreas, and transverse colon, due to centimeter perforation of large sigmoid carcinoma of the stomach. In separating the fixed structures, the abscess, as accidentally entered and immediately closed by suture of the omentum and part of the transverse colon to the anterior surface of the stomach. The mass then as mobilized by dividing the transverse colon laterally between clamps, the duodenum between clamps, and by separating off the outer surface of adherent pancreas. With sufficient division of the gastrohepatic and gastroduodenal and adhesions, the mass consisting of stomach, abscess, and clamped section of transverse colon, as turned out of the abdomen. An end-to-end single clamp anastomosis of the colon, as performed by aligning and clamping together the intestinal ends just beneath the two protecting clamps, back are burned off with cautery. The lower four fifths of the stomach with attached structures and clamps then as resected by the anastomotic Polya single clamp septic method and complementary resection as done. With the exception of small incisional abscess, which healed in 5 days, the patient had an interrupted operative recovery.

#### TOTAL GASTRECTOMY WITH A SINGLE CLAMP (FIG. 5)

The stomach and terminal esophagus are liberated as wide of the lesion as possible (Fig. 5A). The duodenum is divided by cautery between clamps and the stomach is turned out of the abdomen. The distal end of the duodenum is closed carefully by sutures. Two rows of sutures are inserted between the posterior wall of the esophagus near the line of proposed anastomosis and the posterior wall of loop of jejunum about one-half meter from the ligament of Treitz. A clamp then is applied across the esophagus and a fold of the antimesenteric border of the jejunum,

which has been raised by viscera forceps as high as Polya single clamp gastrectomy. A second clamp is applied to the esophagus, which is divided between the clamps and the antimesenteric border of the jejunum burned off by cautery. The end of the esophagus and a contiguous antimesenteric opening on the jejunum now present form a single remaining clamp. An anterior continuous Cushing suture is inserted over the clamp between the esophagus and jejunum, which is tightened as the clamp is withdrawn (Fig. 5B). The line of anastomosis is reinforced by additional anterior sutures and it is supported by means of suture applied between the jejunum and diaphragm (Fig. 5C) with perhaps reinforcing flap turned down from the diaphragm as has been suggested by Lahey.

**Supradaphragmatic esophagogastric anastomosis with single clamp (Fig. 6).** Through a thoracic approach the diaphragm is divided, the upper part of the stomach is liberated, brought into the thorax and divided by cautery between clamps. The lower end of the esophagus is liberated to a point well above the lesion, where two rows of sutures are introduced uniting the posterior surface of the distal end of the stomach, which has been brought through the diaphragm, with the posterior surface of the esophagus (Fig. 6A). The first clamp then is applied across the esophagus between the sutures and the stomach just below its clamped end. A second more distal protective clamp is placed across the esophagus alone. The esophagus is divided between the clamps and the end of the stomach with its clamp burned off by cautery. This leaves the lower end of the esophagus and the upper end of the stomach clamped together in a single clamp over which continuous Cushing suture is inserted as shown in Figure 6B. The Cushing suture is tightened as the clamp is slightly opened and withdrawn. Additional anterior and lateral sutures further lower up the end of the esophagus into the stomach, as shown in Figure 6C. Past experiences impress one with the danger of necrotizing infections from an open suture of the esophagus.

#### ASEPTIC GASTROENTEROSTOMY

Aseptic gastroenterostomy may be performed by crushing together a fold of stomach with a longitudinal fold of jejunum after the plan of a side-to-side intestinal anastomosis. We have used a similar procedure for a cholecystoduodenostomy. In all these anastomoses particular care should be taken in bringing folds of the underlying mesenteric membrane through the clamp otherwise the anastomosis will fail.

## SINGLE CLAMP METHOD FOR RESECTION OF THE HEAD OF THE PANCREAS FOR CANCER

Single clamp method for resection of the head of the pancreas for cancer has the advantage of eliminating soiling of the wound field by bile or gastrointestinal contents which activate pancreatic ferments, and also of simplifying a one stage operation. The lower part of the stomach, the duodenum to its third portion, and the head of the pancreas are liberated *en masse*, the common bile duct is divided between ligatures, and the duodenum is divided near its third portion by cautery between clamps. The pancreas is divided and the retained end is closed with ligatures and sutures and covered by omentum. The liberated portion of stomach, duodenum, and pancreas is turned out of the abdomen. The distal end of the duodenum is closed by inverting sutures with removal of the clamp, and the fundus of the gall bladder is liberated. The posterior surface of the jejunum about one half meter from the ligament of Treitz is sutured across the posterior surface of the stomach. The liberated fundus of the gall bladder is sutured on the anterior surface of the attached jejunum just below its antimesenteric border. A single clamp now is applied across the stomach, jejunum, and gall bladder, narrow segments of the last two with contained lumina projecting above the clamp. A second clamp is applied across the stomach 5 millimeters above the first, and the stomach is divided between the clamps and the projecting folds of jejunum and gall bladder are burned off with cautery. A continuous suture then is introduced over the clamp between the anterior face of the stomach above and the anterior surfaces of the gall bladder and jejunum below, which is tightened as the clamp is withdrawn. Additional anterior sutures are used to reinforce the anastomosis and further to invert the gall bladder and edge of the jejunum into the stomach. The stomach and attached segment of jejunum then are invaginated with the thumb and finger to open the stomach. Obviously the gall bladder also may be applied lateral or posterior to the loop of jejunum.

## ANESTHESIA

Spinal anesthesia, usually with a mixture of from 1 to 1.4 cubic centimeters of 1 per cent pontocaine mixed with an equal quantity of 10 per cent procaine, has been used. For the substandard patient this has been followed by a slow intravenous drip of 5 per cent glucose solution with or without minimal amounts of 2.5 per cent pentothal sodium solution and at times typhed and citrated blood. Local and splanchnic block with 1 per cent epinephrized procaine has been used freely.

## SUTURES

Fine catgut, silk, and plain and stranded alloy steel wire have been used for the inner row of gastric and intestinal sutures. Interrupted No. 36 plain or stranded alloy steel wire has been used for the peritonealizing outer row of sutures as this material does not cause peritoneal reactions or adhesions. The possibility of a suture being burned under the clamp has been considered and a protective strip of wet tape used but no accident has occurred from this source. At this writing there has been no leakage along suture lines following the single clamp method. All abdominal wounds were closed with interrupted usually layer sutures of alloy steel wire.

## HEMORRHAGE

None of the intestinal resections have had intraluminal hemorrhage. After 20 resections of the stomach by the single clamp method, including one for massive hemorrhage, there was little or no bleeding. Then two patients had a heavy hemorrhage through the Wangenstein gastric tube. The stomach had been divided by cautery and the edge of the stomach burned off level with the clamp. Wangenstein leaves a short section of the viscus projecting above the clamp and also applies a high frequency coagulating current to the clamp. He writes that thus he has had no hemorrhage in over 200 resections. After this method was adopted, 3 patients developed necrosis in the abdominal wound, omentum, and region of the duodenum and pancreas, areas in contact with the wet salt pads which were under the clamps to which the high frequency current was applied, probably too intensely and for too long a time. Two of these patients died with degrees of necrosis of the head of the pancreas. One recovered after excision of chalky necrotic tissue from the depths of the abdominal wall and a jejunojejunostomy. We have since used only the galvanocautery.

## DRAINAGE

In all cases a slender, double lumen drainage tube of glass or alloy steel connected to a motor-driven suction pump is left in peritoneal cavity until blood, serum, bile, or other liquids are no longer withdrawn, usually 12 to 24 hours.

## COMPLEMENTAL ENTEROSTOMY

In one stage resections of the colon, especially of the descending colon and sigmoid, the most dangerous of intestinal resections, it is wise to do a complementary appendicostomy or enterostomy at the time of operation. Guided by a hand within the abdomen, the appendix and mesoap-

pendix are pulled through a 1 or 2 centimeter stab wound. Dressings are applied the tip of the appendix or of a cone of cecum cut off and a No. 14 F catheter passed into the cecum tied in, and kept open by irrigation. Otherwise should a patient develop abdominal cramps with localized or diffuse intestinal distention not relieved by Wangenstein aspiration, we promptly deflate by tying a No. 14 F catheter in the appendix or distended bowel. A small muscle-splitting incision made under local anesthesia is used. Gentle irrigations are continued with weak peroxide of hydrogen until the bowel empties. Such operations done without delay have a low mortality and may be life saving. The Miller Abbott tube is not advised for colonic obstruction.

### RESULTS

Sixty-five resections, 35 of the stomach, 30 of the intestine have been done by aseptic single clamp methods as described. There were 9 end-to-end resections of the transverse colon or its flexura, 8 of the ileum, cecum, and ascending colon, 8 of the sigmoid or rectosigmoid, 1 of nearly 9 feet of ileum for carcinoma obstructing bowel and blood supply, 1 of both jejunum and transverse colon, 1 of both sigmoid and ileum, and 2 of both ileum and rectum. All intestinal resections were for carcinoma except one for ileoperitoneal and rectoperitoneal fistulae following operations elsewhere for lymphogranuloma.

Despite the number of necrotic carcinomas removed there were only two operative infections of the abdominal wound and one localized intra-peritoneal abscess (end-to-end resection of the sigmoid). The majority of patients were permitted out of bed by the 5th to 8th post-operative day and to go home on the 11th to 14th day.

In the gastric series 4 patients died in the hospital, 1 of a true lobar pneumonia 8 days after complete gastrectomy for lymphosarcoma which extended into both esophagus and duodenum, a second from bronchopneumonia, gastric hemorrhage and purulent infiltration about the duodenum, following partial gastrectomy for subacute perforation of a chronic duodenal ulcer. The third, a woman of 70 years, and the fourth had the postoperative pancreatitis with extensive fat necrosis, previously mentioned. In the intestinal series there was one death from renal suppression and ileus without peritonitis which may be attributed to the operation. Two died in the hospital from the progress of advanced inoperable carcinoma. One, who had large openings from the bladder, small intestine, and rectum into a cancerous pelvic cavity was given a mea-

sure of comfort for 6 weeks by abdominal resection of the fistulous small bowel and a sigmoidotomy. The second, who had a perforated carcinoma of the sigmoid invading the ileum with chyluria through the anterior abdominal wall, lived about 4 months after a combined M.C. and oblique resection of the ileum without anastomosis breaking down. Both previously had been operated upon elsewhere. The fourth fatal death in the intestinal series, of a 71 year old man, occurred suddenly from the intracranial use of 5 per cent glucose after resection of 10 centimeters of ileocecum. A glucose fever several days previously had been stopped on account of precordial distress. At the second examination the symptoms recurred but the glucose was not discontinued. There was no perforation of the anastomosis was found watertight and obstructed.

### SUMMARY

In a dependable aseptic anastomosis is the best hope of reduction of the mortality and morbidity of gastric and intestinal resections. A single stage single clamp aseptic method is described adaptable to any simple or complicated resection and anastomosis of the gastrointestinal tract including subtotal pancreatectomy. Technical details of the technique to overcome various complications are detailed. From 65 resections of the stomach and intestine the morbidity has been low and mortality attributed to defect in the anastomosis occurred.

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# THE SURGICAL TREATMENT OF CARCINOMA OF THE PHARYNX AND UPPER ESOPHAGUS

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THE pharynx may be divided into three parts: an upper third or nasopharynx, an intermediate or oral pharynx, and a lower portion known as the laryngopharynx or hypopharynx.

Carcinoma of the nasopharynx is not amenable to surgical treatment but some growths involving the oral pharynx or hypopharynx may be treated surgically with a fair prospect of success.

Growths originating in the hypopharynx may early involve the opening of the esophagus and, conversely, upper esophageal growths may spread to the hypopharynx. There is no essential anatomical or histological difference in structure of the esophagus or pharynx, and tumors arising in these areas are identical in their pathology and method of spread.

The vast majority of these tumors are epidermoid carcinomas and are slow growing and relatively late in forming metastases. The method of spread is to neighboring lymph nodes. Distant metastases when occurring are usually found in the advanced stages of the disease.

The usual symptom produced by these tumors is difficulty in swallowing solid or dry foods, often accompanied by a feeling of discomfort in the neck. Occasionally there are voice changes due to edema or involvement of the muscular structure of the larynx.

The upper 3 or 4 inches of the esophagus may be exposed by the same cervical approach as in dealing with pharyngeal lesions.

In cancer of the oral pharynx the larynx may be involved, and in such cases it is essential to remove larynx and pharynx *en bloc*. This is a mutilating type of operation, and many patients and physicians hesitate to undergo or recommend such extensive procedures. However, as it is possible to reconstruct the pharynx so as to permit taking food in a normal manner, the loss of the larynx does not in itself seem too great a sacrifice for the saving of life.

The patients suitable for operation should be prepared by blood transfusions when necessary or by a preliminary course of intravenous therapy.

Figure 1 illustrates a growth situated behind the cricoid and extending up to and involving the aryepiglottic folds and the arytenoids. This case is recorded as Case 1.

The general details of the operation are as follows. The anesthetic is given by mask for the first part of the operation and consists of cyclopropane gas and oxygen, or ether. The exposure is secured by turning back a flap of skin including the platysma, as illustrated in Figure 2. This is based on the right side of the neck, and the skin is reflected so as to expose the sternomastoid muscle. This muscle should then be removed. The isthmus of the thyroid gland is divided and the right lobe is removed, the surrounding tissue being protected by gauze soaked in acriflavine. The trachea is now freed and divided immediately below the cricoid cartilage and the larynx is packed from below. A sterile tube fitted with an inflatable cuff is then placed in the trachea and

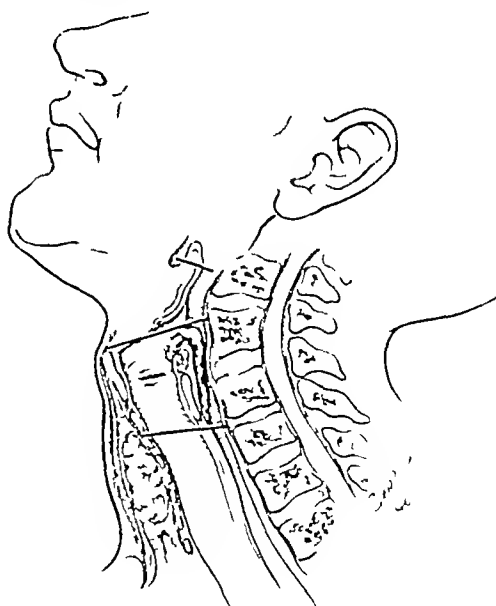


Fig. 1. Extensive retrocricoid lesion involving superior aperture of larynx. For such cases it is necessary to remove larynx and pharynx *en bloc*, as illustrated in text and represented by Case 1.

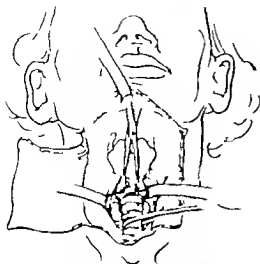


Fig. 2. Large skin flap reflected, incision of thyroid divided, trachea exposed, and position in which it is divided.



Fig. 3. Tracheal tube in position. Pharynx has been divided below thyroid. Esophagus undergoing division.

the cuff is blown up to make it air tight. The anesthetic is then continued by means of this tube (Fig. 3).

The esophagus is mobilized and a tape is passed around it and the entire pharynx is separated from the prevertebral region. The pharynx is then divided just below the hyoid bone or the

body of the hyoid may be removed, though it is best retained if possible. This is illustrated in Figure 3.

The esophagus is divided at a convenient point and the pharynx and larynx are removed in one block. After careful ligation of all bleeding points the skin flap is then held across the prevertebral



Fig. 4. Method of nasopharyngeal flap for reconstruction of pharynx, sutures being placed below. The esophagus is now ready for the placing of suture to lower margin of skin flap.



Fig. 5. First stage completed, showing line of nasopharynx sutured below. Upper suture line to pharynx now correct. Remainder of skin flap being used to close incision as far as possible before Thiersch grafts are applied.



Fig 6 Photograph of specimen from behind showing position of growth (Case 1)



Fig 7 Photograph of specimen from above showing involvement of superior aperture of larynx (Case 1)

space and secured in position by two vertical lines of interrupted catgut sutures about 1 inch apart. The upper edge of the skin flap is sutured to the cut end of the pharynx by a series of interrupted chromic catgut sutures placed close together. The lower edge of the flap is sutured to the esophagus (Fig 4). The remainder of the skin flap is then folded across the middle line and sutured to the deep fascia as illustrated in Figure 5.

A Levine tube is passed down the esophagus to the stomach and the upper end by way of the mouth through the nose. The residual raw surface on the left side of the neck may be made smaller by a series of sutures bringing the skin over for some distance. Thiersch grafts are then used to cover the remaining raw surface.

The patient is fed through the Levine tube. Figure 8, taken 5 weeks after operation, shows the wounds healed and the lateral sinus in the neck. The Thiersch grafts have taken and the tracheal opening is seen just above the sternum.

The next step is closure of the lateral sinus in the neck. Two diagrams (Figs 9 and 10), illustrate the way this is done. The margins of the sinus are undercut slightly and turned in by a series of interrupted catgut sutures so placed that the knots are in the pharynx. A second layer of sutures inverts this suture line further.

The now complete tube is allowed to slip back into the neck, and the skin is closed completely. The photograph (Fig 11) shows the final result. The Levine tube is retained for 2 weeks or until

the wound has healed, after which the patient is allowed first fluids and then 2 weeks later soft foods, and eventually a full diet may be given.

This patient was provided with an artificial larynx but it is well known that such patients acquire a method of speaking in a whisper loud enough to be heard and understood.



Fig 8 Photograph of patient (Case 1), wounds healed, permanent opening of trachea and lateral fissure in neck ready for closure



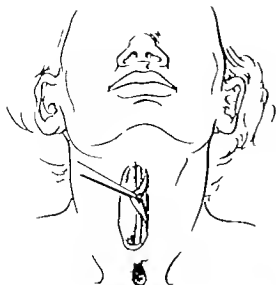


Fig. 9. Method of closing lateral fissure by incising and undercutting the skin.

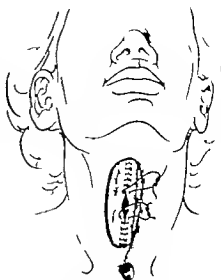


Fig. 10. The margins of the skin tube are here being sutured.

In some cases the growth may be less extensive and it is possible to preserve the larynx. The lower pharynx may be removed and an immediate reconstruction done. The typical site of such lesion is shown in Figure 12. Case

The same type of incision is made. A flap of skin is turned back and a line of cleavage is found



Fig. 11. Photograph of patient (Case ) all wounds healed, reconstruction completed, taking food normally and ready for discharge from hospital.

between the right lobe of the thyroid and the carotid sheath. The thyroid is used as a means of retracting and rolling the larynx and trachea over to the left. The carotid vessels and jugular veins are retracted outward. The superior and inferior thyroid vessels are best divided between ligatures so as to permit a wide separation between structures within the carotid sheath and the larynx. An incision is made through the constrictor muscle along the posterior margin of the wing of the thyroid cartilage and the mucous membrane is separated by blunt dissection from the pyramidal fossa. This dissection is carried across the midline separating mucous membrane from cricoid cartilage and posterior cricoarytenoid muscle as far up as the tips of the arytenoids. The mucous membrane is separated in the left pyriform fossa. An opening is made in the lateral wall of the pharynx and a view of the tumor is obtained. The pharynx is divided above the growth. The esophagus is mobilized below and divided at a convenient level. All bleeding points are carefully ligated, and the flap of skin is placed across the prevertebral region behind the larynx and secured in place by two lines of interrupted catgut suture. The margins of the skin flaps are sutured to the esophagus below and the pharynx above as illustrated in Figure 13. The larynx is allowed to come back into its proper position, the right lobe of the thyroid is replaced, or if large is removed and the remainder of the skin flap is folded across

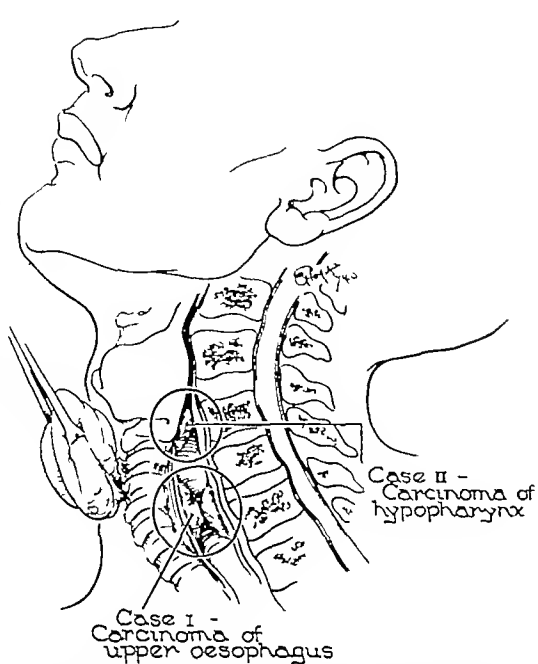


Fig 12 Sites of lesion in conservative operations on retrocricoid growths (Case 2) Also position of upper esophageal lesions (Cases 3 and 4) Larynx is saved, lobe of thyroid used for displacing trachea

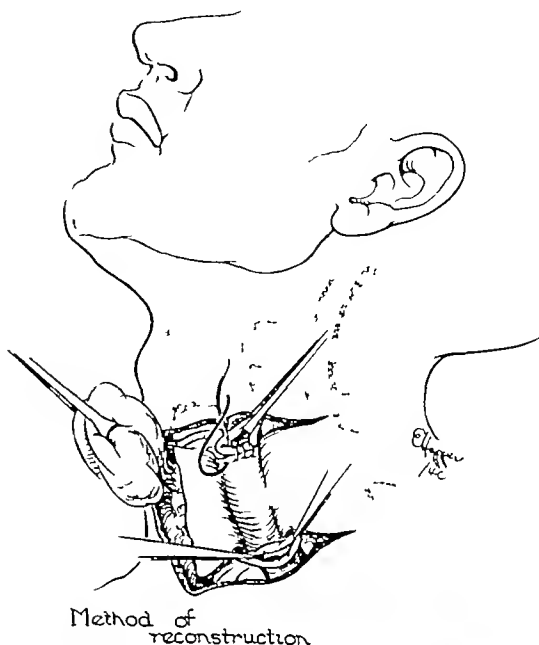


Fig 13 Method of reconstruction used in Cases 2, 3, and 4



Fig 14 Photograph of patient in Case 2 just before closure of lateral fissure.



Fig 15 Reconstruction completed Patient able to take normal food and ready for discharge from hospital (Case 2)



Fig. 6. Radiograph of filling defect in upper esophagus (Case 3).

the thyroid, larynx, and trachea. This leaves a defect in the skin over the left side which can be made smaller by a few sutures pulling the edges together. The balance of the raw surface is covered with Thiersch grafts. A Levine tube is passed down to the stomach and the upper end is



Fig. 8. Photograph of lesion in upper esophagus (Case 3).

brought out through the nose. The lateral flaps in the neck can be closed in about 5 weeks later. The method of doing this has already been described.

Carcinoma of the upper end of the esophagus may be treated in the same manner (Fig. 11, Cases 3 and 4). The esophagus was exposed in the same method of approach, the lower end of the pharynx was mobilized, and the tumor was removed. The reconstruction is somewhat more



Fig. 7. Photograph of patient after excision of upper esophagus, ready for closure of lateral incision (Case 3).



Fig. 9. Photograph of patient 14 days after operation, ready to leave hospital (Case 3).



Fig 20 Roentgenogram showing filling defect produced by polypoid growth in upper esophagus (Case 4)

than in the case of growths originating in the pharynx. The skin flap is made use of in the same way for reconstruction of the esophagus. Figure 13 serves to illustrate this equally well.

#### CASE REPORTS

**CASE 1** (Figs 6, 7, 8 and 11) Mrs. Eliz. B., aged 50 years, was admitted to the hospital November, 1934, complaining of hoarseness and pains in her neck for 6 months. The trouble began with a feeling of soreness of the left side of the neck below the jaw and difficulty in swallowing solid

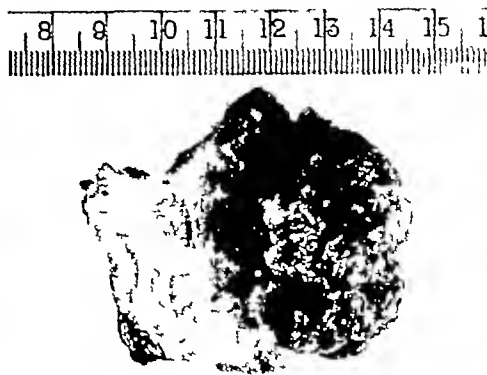


Fig 22 Photograph of specimen removed at operation (Case 4)

food. Difficulty in swallowing had increased. She had lost 15 pounds in weight in past 4 months. Laryngoscopic examination revealed a tumor in the retrocricoid region, extending upward to the superior aperture of the larynx and involving the left pyriform fossa. Biopsy specimen showed epidermoid carcinoma.

Operation was performed December 19, 1934. Exposure was made by flap of skin based on the right side. The isthmus of the thyroid was divided, the trachea exposed. The trachea was divided below the cricoid. The pharynx was opened above the upper border of the thyroid. The pharynx was divided below the hyoid. The esophagus was divided about  $1\frac{1}{2}$  inches below its upper end. Immediate first stage reconstruction of pharynx and esophagus was done. The cut end of the trachea was sutured to the skin. On April 2, 1935, closure of lateral fissure in the neck was done. On April 15, 1935, the Levine tube was removed. Patient was allowed to swallow fluids. On April 20, 1935, she was taking soft diet. She was discharged April 27, 1935, at which time she was taking full diet.

This patient lived for 2 years but died of metastases in her neck.

**CASE 2** (Figs 14 and 15) Mrs. Emily H., aged 62 years, admitted to the hospital November 18, 1939. She



Fig 21 Photograph of patient (Case 4) just before closure of lateral fissure



Fig 23 Photograph of patient, lateral fissure closed, Levine tube to be removed (Case 4)

complained of difficulty in swallowing for 4 years. Inability to swallow solid foods for past 3 months and recently difficulty in getting fluids down. On examination there was found a growth involving the lower pharynx and left pyriform fossa, which bled easily. Biopsy specimen showed epidermoid carcinoma.

Operation was performed on December 5, 1939. The larynx and trachea were displaced to the left. The pharynx was divided just below the superior aperture of the larynx. The mucous membrane was separated from the pyriform fossa and back of the cricoid cartilage. The esophagus was divided 1 inch below its upper end, and an immediate reconstruction of the pharynx and upper esophagus was done in the manner described.

Figure 4 shows patient 5 weeks after operation. His skin was well healed. Levine tube passing down to the stomach through the nose as means of feeding the patient. On February 9, 1940, the lateral fissure in the neck was closed, thus completely reconstructing the esophagus and pharynx. On March 20, 1940, the Levine tube was removed. Patient was allowed to take fluids by mouth at first, followed by soft foods in week, and so on full diet in the third week, care being taken to cut up food into small pieces. On January 5, 1940 Figure 5 was taken, 4 months after final operation on return to follow-up clinic. Patient was able to take all types of food satisfactorily. In February, 1941 patient was in good health and taking normal diet.

CASE 3 (Figs. 6, 7, 8 and 9.) Mrs. J. H., aged 55 years, was admitted to the hospital in March, 1939. She had suffered from discomfort in swallowing for about a year. The condition gradually increased until on admission only fluids could be taken. Esophagoscopy examination showed a tumor about 3 1/2 inches below the orifice of the esophagus. Biopsy specimen showed epidermoid carcinoma. The x-ray film showed filling defect (Fig. 6). Operation was performed on March 23, 1939. The larynx and trachea were displaced to the left. The lower pharynx and upper 3 1/4 inches of esophagus were removed (Fig. 6). Immediate first stage reconstruction was done. On May 3, 1939, the photograph, Figure 7 was made and showed the wound healed. The lateral fissure was ready for closing. On June 9, 1939, the fissure was closed and the Levine tube was removed. Patient was able to take fluids (Fig. 9). She remained ill for 4 months, and then began to have difficulty in swallowing. A tumor appeared from below the clavicle, attached to, and infiltrating, the trachea. This was believed to be due to development of secondary carcinoma in glands invading trachea. She died in September, 1940.

CASE 4 (Figs. 10, 11, and 12.) Mrs. S. McC., aged 58 years, was admitted to the hospital July 1940, complaining of difficulty in swallowing for 8 months. She had pain in region of the suprasternal notch. Her previous x-ray examination showed filling defect in the upper end of the esophagus (Fig. 10). Esophagoscopy examination revealed polypoid growth 1 inch below the upper esophageal sphincter. Biopsy specimen showed epidermoid carcinoma.

Operation was performed August 7, 1941, and consisted of removal of the lower pharynx and upper 3 inches of the esophagus (Fig. 11) with first stage of reconstruction done immediately. Larynx and trachea were displaced by method already described. Figure 12 shows the wound in the neck healed. The lateral fissure was ready for closing. On October 14, 1941, the lateral fissure closed (Fig. 12) showing the condition when patient was discharged from hospital. She was able to take solid food with comfort. In February, 1942 patient was alive and well taking normal diet.

#### SUMMARY

Methods of removing suitable growths involving the lower pharynx and upper esophagus are described. When the larynx is involved, a complete removal of larynx and pharynx is suggested as illustrated. Case 1. A conservative operation for removal of early hypopharyngeal carcinoma, preserving the larynx, is described in Case 2. Tumors at the upper end of the esophagus may be removed as illustrated in Cases 3 and 4. In all cases it was possible to reconstruct the pharynx and upper esophagus so as to permit the taking of normal food. Unfortunately many cases are not by the surgeon in the advanced stage but with early diagnosis and operation without delay there should be a reasonable chance of effecting a cure. In our cases, because of respiratory difficulty in the first day or two after operation, a tracheotomy has been necessary as a temporary measure. Indeed, I believe that it is wise to do a tracheotomy in all cases. The tube may usually be removed after about a week. The fact that the pharynx and esophagus can be reconstructed should encourage both physician and patient.

# THE LAMINAGRAPH AS AN AID IN THE TREATMENT OF CHRONIC OSTEOMYELITIS

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ONE of the difficulties often encountered in the treatment of chronic osteomyelitis is the accurate localization of abscesses which give rise to recurrent attacks of pain, swelling, and fever. These cavities contain pus, or less frequently granulation tissue, usually in the midst of thickened, sclerotic bone, the density of which is such that ordinary x-ray films fail to reveal them. One or more sinuses may communicate with the abscess cavity, but the tract often is so long and tortuous that it cannot be clearly followed in the ordinary roentgenogram even after injection with an opaque substance. Efforts to find the cavity by excavation of the bone without any definite knowledge of its whereabouts usually are unsuccessful.

When a laminagraph was acquired by the New York Orthopaedic Hospital in the spring of 1941, it occurred to us that this instrument, which is capable of making a clear and detailed roentgenogram of any plane desired through any substance, might be used to solve this problem. The fundamental principle<sup>1</sup> of the laminagraph is that the tube and film move during exposure in such a way that the roentgenographic shadow of a selected plane in a body remains stationary on the moving film while the shadows of all other planes have a relative displacement on the film, and are therefore blurred to varying amounts, depending mainly on the distance of such planes from the one selected. The effect of motion and its attendant blurring is two-fold. First, it permits good visualization of objects which would otherwise be obscured, when roentgenographed in the normal position, by large dense overlying or underlying structures in a direct line with the desired object and target. During laminagraphic motion an appreciable part of the exposure is made while obscuring structures are not in a direct line with the object to be visualized, and therefore, clearer views of this object are obtained. Second, it minimizes the disturbing effect of superimposed shadows because it blurs the image of fine structures not in the plane to be visualized.

**CASE 1.** The first patient was a 19 year old girl (Fig 1), who had had osteomyelitis of the right femur since the age of 13 months. At no time since the onset had the disease become completely healed. The entire extent of the femur was involved. The bone was enlarged, thickened, sclerosed, and was deformed as a result of the infection and numerous operations. There was a bony ankylosis of the knee. Several sinuses opened and discharged from time to time. The most troublesome feature of the case was recurrent attacks of pain and swelling in the region of the knee, and on these occasions a discharge usually took place from a sinus on the inner side of the knee. A number of operations had been performed, both in this and in other hospitals, in an effort to eradicate the focus of infection giving rise to these exacerbations. The last attack upon the bone had been made elsewhere the previous summer. After each of these operations the pain was made more severe.

The laminagraph was used showing planes of the lower part of the femur at intervals of 1 centimeter. They revealed a cavity in the outer portion of the bone and showed a sinus tract communicating with it and extending obliquely inward to the medial surface. These facts were made more clear by droplets of lipiodol which had been injected the previous summer. The sinus tract was injected with methylene blue and the bone was explored. Upon the cutting away of extremely hard, sclerotic bone above the lateral condyle, an abscess cavity containing thick, yellow pus tinged by methylene blue was found in the place indicated by the laminagraphs. This cavity and the sinus tract communicating with it were thoroughly excavated. The cavity was lightly packed with sulfathiazol. Recovery was marked by the absence of pain and fever and ended with obliteration of the sinus tract by granulation tissue over which epithelium grew.

The second case with 2 separate abscesses demonstrates the possibility of more than one abscess cavity in bone.

**CASE 2.** This patient is a 33 year old female who was admitted in 1933 for arthrotomy of the left knee because of suppurative arthritis and popliteal abscess. In 1935 cardinal signs of inflammation reappeared in the left knee, but this subsided with rest and hot packs. She returned again in 1940 with a popliteal abscess which was incised and drained. At the same time the lower femur was explored but there was no evidence of active osteomyelitis. On the 11th postoperative day a fracture occurred through the distal shaft of the femur when the patient started to sit down on a chair. Good reduction of the fracture was obtained by the insertion of tongs in the supracondylar region with traction. The fracture healed. The patient again returned in April, 1941, at which time there were five draining sinuses in the lower femoral region. Each sinus was injected with lipiodol and laminagraphs were obtained. Incision and drainage followed with confirmation of two bone abscesses as demonstrated by the laminagraphs.

**CASE 3.** Male aged 40 years (Fig 2). At the age of 7 the right knee became swollen and painful, the swelling sub-

From the New York Orthopaedic Dispensary and Hospital  
<sup>1</sup>Jean Kieffer. *Am. J. Roentg.* 1938 39:479-513

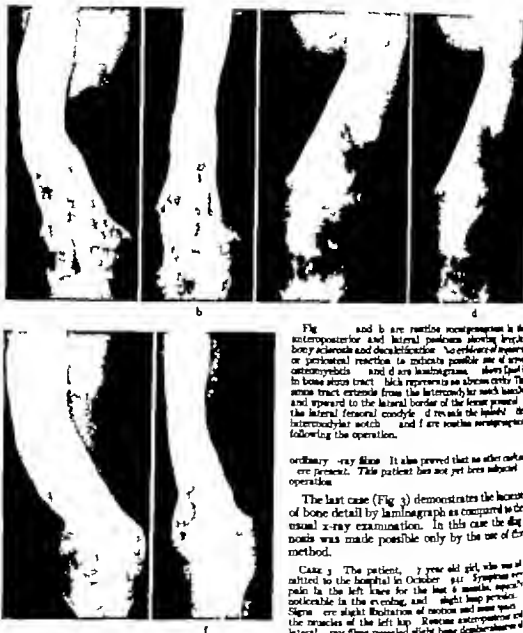


Fig. 2. (a) and (b) are routine roentgenograms in the anteroposterior and lateral positions showing bony sclerosis and decalcification. No evidence of sequestra or periosteal reaction is indicative possible site of an osteomyelitis. (c) and (d) are laminograms, shown (a) in bone stress tract which represents an abscess cavity. The same tract extends from the intercondylar notch backward and upward to the lateral border of the femur proximal to the lateral femoral condyle. (d) reveals the location of the intercondylar notch. (e) and (f) are routine roentgenograms following the operation.

ordinary x-ray films. It also proved that no other culture were present. This patient has not yet been subjected to operation.

The last case (Fig. 3) demonstrates the increase of bone detail by laminagraph as compared to the usual x-ray examination. In this case the diagnosis was made possible only by the use of this method.

CASE 3. The patient, a 7 year old girl, who was admitted to the hospital in October, 1931. Symptoms were pain in the left knee for the last 6 months, especially noticeable in the evening, and slight limp periods. Signs were slight limitation of motion and some tenderness of the muscles of the left leg. Routine anteroposterior and lateral x-ray films revealed slight bone demineralization of the left femoral neck. The tuberculin test was negative, sedimentation rate was 3, and the white blood count was 12,000 with 47 per cent neutrophils, 49 per cent lymphocytes, 3 per cent mononuclears, and 1 per cent eosinophils. The laminograms showed a cavity in the middle third of the femur, about 1 centimeter in diameter. Surgical exploration revealed moderate increase of clear yellow fluid in the joint, and synovial membrane was moderately hyperplastic. Several drill holes were made in the region of the cavity.

During the 4 months at the age of 14, popliteal abscess developed and it was incised. The patient was free of recurrence until 1937. In August, 1938, bone abscess in the lower end of the femur which communicated with popliteal abscess was explored and drained. However drainage has continued up to the present time. Laminographic examination was made after the incision of the popliteal of the two draining sinuses. It demonstrated cavity in the lower end of the femur which also was shown in the



Fig 2 a and b are roentgenograms showing irregular bony sclerosis and decalcification in lower third of femur c and d are laminagrams which show the lipiodol within the large bone abscess in lower femur following the injection of sinuses e and f are plain roentgenograms after the injection of the lipiodol

The media appears to be within the bone and not so clearly demonstrated as on the laminagrams Then the opaque media on the skin surface may cause confusing shadows on plain roentgenograms but not in the laminagrams



Fig 3 a and b represent routine anteroposterior and lateral roentgenograms which show irregular decalcification of the bone throughout the area of the femoral neck. c and d are laminagrams which were taken at

different levels c reveals a 1 centimeter cavity which is in the neck of the femur c is in better focus than d The cavity is not clearly discernible on routine roentgenograms

#### CONCLUSIONS

- 1 An increase of bone detail is available by the use of the laminagraph
- 2 The laminagraph affords better localization of a bone abscess with regard to both site and level

3 The laminagraph may help in the prevention of operation for just one abscess when more may be present

4 The use of lipiodol in draining sinuses is suggested when roentgenographic examinations are made



# A ROENTGENOLOGICAL STUDY OF THE POSTOPERATIVE ABDOMEN

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**A** DISTENTION varying in degree very frequently develops in from 24 to 66 hours following abdominal surgery. The operative procedure may have been of such a magnitude that a moderate degree of distention is anticipated by the surgeon—the so called gas pains. Too frequently the distention continues or becomes quite severe and may be accompanied by pain. But this, too, is accepted as the usual aftermath of a major abdominal surgical procedure. However a certain percentage of these cases, as will be shown later, are of a mechanical obstructive nature and not a paralytic ileus brought on by stimulation of the sympathetic nerve.

Fortunately only a small percentage of postoperative distention is based on a mechanical block. Of this small group only part of them progress to require active therapy. It is this latter smaller group that we are interested in because if a mechanical obstruction can be diagnosed early in a postoperative course and active therapy instituted the late sequelae of a mechanical obstruction can be obviated. Distention of the colon is not included in this paper although we have noted that a mechanical obstruction of the colon, by back pressure, can cause small bowel distention giving the appearance of a mechanical obstruction.

Ochsner showed that if a mechanical block of the small bowel is allowed to continue untreated and the obstruction is low the increasing interluminary pressure may cause pressure necrosis, gangrene of the bowel, peritonitis, and death. If the obstruction is high vomiting will quickly occur with the resultant loss of fluid and chloride. This may also cause the death of the patient (Wangensteen). In a uncomplicated case mechanical obstruction can be clinically differentiated from paralytic ileus by the increased peristalsis of the bowel. In the postoperative patient a clinical differential diagnosis is more difficult. Mechanical obstruction may exist with little or no audible peristalsis and may be present without appreciable distention.

The causes of postoperative mechanical obstruction are numerous. An adhesive band may have been overlooked at the time of the original operation. A small amount of fibrin may cause two loops of bowel to become adherent and so set up a mechanical obstruction. An internal herniation may occur. A loop of bowel may become adherent to a raw surface which had not been properly peritonealized. Another case not often considered is a local focus of infection pushing the adjoining segment of small intestine by its toxic action on the muscle wall (Derrine). This causes a mechanical block, producing a paralytic distention without local symptoms or signs. The bowel may become adherent to the local infection. At the time when upper incision section were commonly performed, a great many obstructions occurred from adhesions of the bowel to the operative line by plastic lymph.

The clinical signs of mechanical obstruction may not appear until the 6th or 7th day after operation. Considering the seriousness of a mechanical obstruction, one must be concerned about every case of distention and use every means possible to differentiate the type. This can be done by a simple x-ray examination of the abdomen. In a recent article Braun and one of us (J. Levy) outlined the differential diagnosis of mechanical block from paralytic ileus, as viewed on the x-ray film. They are as follows.

Mechanical obstruction	Paralytic ileus
1. Continuous distention to the point of obstruction	Scattered loops of distended small and large bowel
2. Loops few and large	Loops many and small
3. Dynamic appearance of bowel	3. Static appearance of bowel

Many questions arose as to the accuracy of these findings especially when a few postoperative cases showed evidence by x-ray examination of mechanical block while the patient appeared well clinically. Some of the questions desired an answer were (1) How much importance can be placed on the x-ray findings in a case of obstruction? (2) What is the nature of postoperative distention? (3) Do factors such as anesthesia, type of surgery, technique of the surgeon or postoperative

treatment play a part in the occurrence of postoperative distention? (4) If a mechanical block is surgically treated, how soon does the bowel return to normal, as viewed on the film? (5) How much attention must be paid to a positive x-ray diagnosis of mechanical obstruction with minimal clinical symptoms? (6) What is the appearance of the small bowel on the x-ray film when part of it has been resected?

While we have not completely answered all these questions, we feel that by the cases we have studied, we can throw some light on the subject and give a working basis for treatment. Since the goal of all treatment is to reduce morbidity and mortality, it is most important that mechanical block be recognized early and that treatment be instituted to relieve the distention, as this is the type of condition which may lead to a fatality if untreated.

This study is based on 107 cases from 3 sources of material. First, bed-side x-ray examinations were done on an unselected group of postoperative cases on the first day following surgery and every subsequent day through the fifth. If gas appeared in the small bowel during this period films were taken daily until the gas disappeared. If the patient had any abdominal distress, films were taken daily until the patient felt well.

The second group in this series comprised all those patients who entered the hospital with distention and a questionable diagnosis of bowel obstruction. This group offered a valuable opportunity to test the accuracy of the diagnosis, because most of these patients went to surgery within a few hours so that it was possible for us to compare the appearance of the bowel on the x-ray film with that found at surgery. This is most important. If we are to learn anything at all about x-ray appearance of the bowel, we must have confirmation as soon as possible after the film is taken. Conditions change rapidly in the abdomen with bowel obstruction. From hour to hour, the x-ray findings and the clinical picture may change. In comparatively short time, a simple mechanical bowel obstruction may terminate in peritonitis with a paralytic ileus. Obviously, comparing a film to what may be found at surgery a day or two later or comparing a film to the findings of a postmortem examination days or weeks later will lead to erroneous conclusions with reference to the accuracy of the x-ray interpretation.

The third group of cases are those in which postoperative symptoms appeared of such a nature as to warrant x-ray investigations for a suspected bowel obstruction.

#### GROUP I UNSELECTED CASES STUDIED AFTER OPERATION

In all, 20 patients were studied by x-ray examination of the abdomen after operation. The type of operation varied; they were all abdominal except for one which was a repair of an inguinal hernia. The operations were performed by 7 surgeons, so no one operator can be blamed for "rough handling" of the bowel. While this group is too small from which to draw conclusions, certain impressions do stand out.

First, irrespective of age or type of surgery, distended bowel of a paralytic nature followed abdominal surgery in 15 of the 20 cases, or 75 per cent. All of these patients but one complained of "gas pains." This one case showed only a mild distention of the bowel by x-ray. In other words, all patients who complained of gas pains, had x-ray evidence of distention. In 3 cases without x-ray evidence of distention, there was no discomfort on the part of the patient. Every patient complaining of distention and pain after operation is a potential case of mechanical bowel obstruction. A differential diagnosis between mechanical obstruction and paralytic ileus can be made by x-ray examination, as here mentioned. The x-ray findings of distention usually appeared on the first postoperative day except in 1 patient in whom the gas did not appear on the film until the third day. The distention usually lasted 3 days. It is of interest to note that the complaints of the patient did not occur with the appearance of gas in the bowel as found on the film but followed a day or two later. This raises a question: Is the pain due to peristalsis attempting to overcome the distention rather than distress from the distention itself?

Second, the type of anesthesia seemed to play no part. Subarachnoid, avertin, cyclopropane, ether, novocain were all employed. At times one agent was used, in other cases two were used in combination: subarachnoid-ether, subarachnoid-cyclopropane, avertin-cyclopropane. No one type of anesthesia or combination of agents showed more or less distention.

Two cases in this series called our attention to a fact which to our knowledge has never been mentioned in the literature. These 2 patients had few or no symptoms after operation and under ordinary circumstances would have been regarded as following the usual postoperative course. However, the postoperative x-ray examination showed a low mechanical bowel obstruction. This was early in our work, and in view of the clinical well-being of both the patients showing no clinical evidence of obstruction, with normal temperature

and pulse rate the x-ray findings were disregarded.

The first case, a woman, aged 69 years, who entered the hospital with strangulated femoral hernia. Her condition was so poor that it was decided to attempt return of viability of the strangulated bowel after it was freed rather than proceed with resection. For the first 3 days after operation she had moderate discomfort, following which she felt ill and her general condition improved. Yet consecutive x-ray films showed continued evidence of mechanical obstruction. On the 14th post-operative day the patient condition suddenly became poor. There was rise in pulse rate, respirations increased, and she had nausea and vomiting. A Miller Abbott tube was passed and the distressing symptoms were almost immediately relieved. Likewise, the x-ray evidence of small bowel distention was gone.

The second case was one in which an appendectomy had been performed.

The appendix was ruptured and lying in an anomalous position beneath the band of mesenteric. There were also compensatory bands in the pelvis. Films are taken immediately following surgery. The patient felt ill but the x-ray films demonstrated mechanical obstruction. Again, the x-ray findings are disregarded in view of the absence of clinical symptoms of obstruction. The patient continued to feel ill up to the 3rd day after operation. On this day he complained of abdominal pain; there was rise in pulse rate and temperature. The abdomen was not distended but the x-ray film showed persistent evidence of mechanical obstruction. Wangenstein section was unsuccessful. On the 14th postoperative day he was again operated upon and mechanical obstruction due to band as found. An enterocolostomy was performed to relieve the distention. X-ray films taken after the second operation showed no evidence of block. He made an uneventful recovery.

Both of these cases showed a mechanical obstruction by x-ray immediately following surgery. The patients experienced no discomfort nor any symptoms indicating bowel obstruction which must have been partial as there were bowel movements. Why the distention went as far as the 12th to 14th day without symptoms and why the sudden collapse of the patients are questions that we are not prepared to answer at this time. It is not the block itself. Of 3 cases not included in this group where bowel resection was carried out, follow-up x-ray examination showed distention of a mechanical nature proximal to the anastomosis for 5 days in 2 cases and 7 days in the other. The distention was due to the edema along the suture line of the anastomosis causing a partial obstruction. Clinical symptoms of obstruction were present at any time. Wangenstein has shown that if the bowel is kept deflated by intubation and the body fluids and chlorides maintained to their normal levels, patients can live in spite of bowel obstruction. The 2 patients mentioned did not have the distention to the extent of causing a pressure necrosis with gangrene of the bowel. The turn of symptoms was sudden. If we do not con-

sider the block with absorption of toxins as a factor we may consider the neurogenic factor advanced by Antonie and Lawrence. Wilky experimental denervated closed loops of intestine then concluded that the sudden collapse was due to afferent impulses from the distended loops which caused vomiting with fall of pressure. Sudden collapse was not due to any specific toxin. Whatever the cause, it is sufficient to accept the fact that a mechanical small bowel obstruction can exist without symptoms. It should be detected as soon as diagnosed and treatment should be withheld until symptoms of collapse appear.

#### GROUP II. CASES ENTERING HOSPITAL WITH DOMINAL DISTENTION AND SUSPECTED MECHANICAL OBSTRUCTION

This was the largest group, consisting of 44 cases. Some of these patients went to surgery and gave us the opportunity to check the accuracy of our findings. The diagnosis of mechanical obstruction was made in 30 cases. Twenty-three of these were operated upon within the subsequent 3 hours. The causes of the obstruction were found at surgery to be: adhesions from prior operations, 5; large bowel block by cancer, 1; back pressure into the small bowel, 5; diverticulitis, 1; carcinoma implants, 3; appendicitis, 1; internal hernia, 3; ileocolic intussusception, 1; intussusception of Meckel's diverticulum, 1; gallstone impacted at terminal ileum, 1; perforated bladder with adherent small bowel, 1; mesenteric divertitis with glands in right lower quadrant.

The one case in this series which did not go to surgery had negative x-ray findings the following day and the patient was free of symptoms. However, this does not completely rule out the diagnosis of mechanical obstruction. Very few of the hands causing an obstruction may free themselves. A volvulus may not release itself. A hernia may reduce itself. Therefore, it is not enough to assume that in this case the obstruction relieved itself as shown by the subsequent negative x-ray findings.

Seven cases of this group were diagnosed as enteric as paralytic ileus. Six of these went to surgery and the findings were: acute appendicitis, 1; perforated duodenal ulcer, 1; sigmoid hernia, 1; bleeding follicular cyst, 1; mesenteric thickening with gangrenous lower ileum. In none of these cases was mechanical obstruction found. It is pointed out, paralytic ileus can be caused by a reflex affecting the autonomic nervous system. The finding of paralytic ileus in these cases is not incompatible with the pathological condition found at surgery.

## VITAMIN E IN THE PROPHYLAXIS OF ABRUPTIO PLACENTAE

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**F**OR years abruptio placentae has been defined as the premature separation of all or a large portion of the normally implanted placenta. This occurs suddenly, often on the basis of a late pregnancy toxemia, and is characterized by uterine pain and tenderness, bleeding, and even shock. Because the onset of this severe condition is held to be catastrophic, it is necessarily unforeseen. Therefore, the counter measures advised tend to be radical, with results which are not always happy for the mother and certainly not for the child. In this deplorable state of affairs it is obvious that premonitory signs and symptoms, if there be such, should be sought.

In 1937 the author (3, 4) called attention to the significance of the very common small areas of uterine tenderness complained of even in early pregnancies, and advanced reasons for ascribing the development of these to small placental detachments. If, as is the case, these areas of localized tenderness are often associated with traces of small retroplacental hemorrhages when the placenta comes to inspection, there is no good reason why the use of the term abruptio should be restricted to the more extensive subplacental hemorrhages only. Should we take eclampsia and pre-eclampsia for an analogy, these early, small, tender placental detachments might be referred to as pre abruptios, and be the very phenomena to be recognized in the anticipation and prophylaxis of the major catastrophes. One suspects that McKelvey refers to these when he speaks of "miniature premature separations." Although he claims they produce "no clinical symptoms" he adds that they offer "the best available material for the study of the mechanism of premature separation. Larger hemorrhages lead to clinical premature separation." He finds evidence to suggest that "the basic circumstances inherent in premature separation of the placenta are present in most, if not all, human placentas." We think that the mild abruptios are very common.

Even in a small series of pregnancies, women are found having areas of uterine tenderness of all degrees of severity, and these women may bleed extensively, only a little, or not at all. These tender areas may disappear, only to recur one or

many times in the same pregnancy. *But the always recur at the same place on the uterine wall* and on a few occasions this has been demonstrated to be actually the placental site (4). If the first tenderness is untreated or inadequately treated its later phases or recurrences are often accompanied by toxemia. Sometimes, but not always, such a woman goes on to the development of a characteristic and conventional abruptio placentae. Some of the appended case histories illustrate this. However, this disastrous sequence need not always follow, as will be explained later.

There is no good reason why a dogmatic and entirely artificial line should be drawn, on one side of which lie women exhibiting only small areas of uterine pain and tenderness, with or without "spotting" or hemorrhage, and with only such early evidences of toxemia as excessive weight gain or blood pressures on the high side of "normal." On the other side we traditionally have put the placental catastrophes, usually having great and extensive tenderness and pain or shock, slight or marked hemorrhage, and severe toxemia. Moreover, the typical pathological picture of the placenta in abruptio placentae is not confined to placentas expelled in the last trimester of pregnancy. It has been seen by every obstetrician in the placentae of simple miscarriages and even may be recognized in the decidua basalis of spontaneous abortions. Perhaps for that reason, De Lee has said picturesquely that an abruptio is merely an "abortion at or near term." The converse is equally true, of course, namely that the placenta in even the most typical clinical case of abruptio at term or near term may display nothing to substantiate the clinical diagnosis.

Obstetricians have too generally ignored the small, discrete areas of uterine tenderness here referred to. These have been summarily dismissed as "adhesions," "the baby kicking," "stretching," or even, when severe and in the right lower quadrant, as "appendicitis." The writer has seen a number of these "appendicitis" cases in consultation—on 2 occasions after the appendix had been removed (1 of these in the physician's wife mentioned in Case 3)! The differential diagnosis is usually very simple, if the

be remembered that appendiceal tenderness in pregnancy is paratubal but the tenderness due to placental detachment is uterine.

#### RELATION TO VITAMIN E DEFICIENCY

Quite early in his studies on vitamin E deficiency it became apparent to the writer (5) that uterine tenderness was almost always the first sign of vitamin E deficiency in human pregnancy that it could always be relieved by the prompt administration of enough vitamin E and that if it recurred it was evidence of escape from vitamin E control. As extensive blood studies of the vitamin E-estrogen equilibrium were continued it was seen that, like spontaneous abortion, abruptio placentae of either the classical degree of severity or of the mild degree described here was usually associated with vitamin E deficiency and its concomitant estrogen excess. Of course, abruptio placentae of the most typical sort can occur in the absence of any one of its major criteria, viz. pale tenderness, shock, external hemorrhage, toxemia, or a high blood estrogen value. When blood studies in early pregnancy revealed this vitamin E-estrogen imbalance, it was at once anticipated (6) that somewhere in the future of that pregnancy lay an abortion, miscarriage, premature delivery, nonclimptic toxemia, abruptio placentae, or anomalous child. Much the same idea suggested to Young the useful and graphic concept of the "abortion sequence." The point to be stressed is that the danger of abruptio placentae, classical or mild, can almost always be foreseen and, as what follows may indicate, can usually be prevented. The appended case reports are intended to illustrate that (a) The first clinical sign of placental detachment is a localized area of uterine tenderness, with or without slight bleeding or slight toxemia. (b) Abruptio placentae can often be foreseen even earlier in pregnancy by means of a blood estrogen assay. (c) Such an assay is *quasi* *new* for its early recognition. (d) If the early signs are neglected the patient may go on to display classical abruptio placentae. (e) The early phenomena disappear promptly if enough vitamin E is administered at once. (f) The vitamin E used must be a potent preparation. The dose usually rises as pregnancy proceeds and must always be the dose required to control symptoms in that particular woman's pregnancy not just a standard dose. It must be given until delivery.

#### CASE HISTORIES

**CASE 1.** This patient, physician W., aged 27 years, had had spontaneous abortion, in 1934. In 1935 she conceived again, her last menses coming May 8. Her blood estrogen was positive on October 8. On November 30 she

suddenly developed severe labor pains, lasting for 12 hours. They subsided after large doses of best form of barbiturate kept on small dose then forth. On January 1 she suddenly awakened, crying, in tearing pain in her right lower quadrant. Violent fetal movements, uterine tenderness on the lower right aspect. Her uterus had the characteristic lymenous consistency. Her blood estrogen was still high, and found that the best form of capsules she had been taking were old and therefore deteriorated. She was given large doses of fresh, best, best form on January 3, and the lymenous consistency of the uterus disappeared by nightfall. Her blood pressure then was 110/80 and there was no albuminuria, but the tenderness and pain remained about the same.

She was much better by the 4th but it was decided to induce labor as this was the first case of this degree of severity that had attempted to handle with vitamin E. The membranes were ruptured artificially on 5 and pinkish, greenish anesthetic fluid escaped. Some pains soon began, and all night she had tremendous uterine contractions and pain. No cervical dilatation ensued, the became exhausted, and, after consultation at 6 a.m. on the 5th, cesarean section was decided on.

When the abdomen was opened herniations, redness in diameter, were found on the anterior aspect of the uterus near the uterine line. When the anterior flap of visceral peritoneum was elevated and as gently directed off with the finger small herniations appeared beneath the uterine wall as touched. When the lower segment was picked up with Albee forceps it tore like butter. A 6 pound ounce girl in fair condition was slowly extracted. The uterine wall as very hard to cross fingers could scarcely hold on account of its extreme brittleness. The patient had some psychosis on the 4th day postpartum. Others in her own experience as overrational and the child was born normal. There has been no further pregnancies.

**CASE 2.** This woman, physician W., aged 30 years, had had a girl and boy before, the latter pregnancy overrational and under my care. With her third pregnancy the last menstruation began on April 21, 1936. Her blood estrogen was positive when she was first seen on June 9, her blood pressure 100/74, her weight 135 pounds, and her urinal clear. She was promptly put on both wheat germ oil preparation. There was nothing in early pregnancy. The August 4 she complained that her abdomen felt all the time as if it had been kicked. Her weight then was 135 and her pressure 100/74. When seen on September 1 she mentioned that she had had severe, palpable, uterine contractions for the preceding 10 days, with severe headache but no bleeding. She was given big doses of the best form of oil but it had no effect. We found that no precautions as to its freshness and deterioration had been taken. Accordingly she was given Kelly's oil beginning on the 7th, tablespoons per day. The uterine cramps ceased, although considerable diffuse uterine tenderness persisted. Her pelvic symphysis became tender and locomotion correspondingly difficult. Her blood pressure, weight, and urinal remained normal. On January 1 she took castor oil and vomited, nearly precipitating, in 34 hours there, diarrhetic female waste of 6 pounds and 5 pounds, respectively. The placenta which showed small, old, marginal infarct on the maternal aspect, about 2 centimeters in diameter. Mother and child did all.

**CASE 3.** This physician W., aged 27 years, physician, registered last on September 9, 1936. I first saw her on January 7, 1937. She gave history of appendicitis on October 5 (the removal of normal appendix). As her "appendicitis" was left undisturbed as right-sided before the operation, she had asked her surgeon to explore

the left as well as the right side of her abdomen. Her pain continued after operation just as before.

When she was first seen she was 4½ lunar months' pregnant, had felt life 3 days before, had a definitely tender area near the right cornu, had a blood pressure of 136/84, and a negative estrogen test. She had bled a few drops on November 8 after a motor trip.

In spite of the blood test she was put on Kelly's wheat germ oil throughout her pregnancy. She had no idiosyncrasy to it and promptly developed an itchy rash, but it was felt that she dare not discontinue it. There were attacks of cholecystitis also. On April 27 her pressure had risen to 150/90 and her weight was 170 pounds. There was no albuminuria at any time. She was raised to a table spoon of oil per day. She soon felt 'like ice in the shade' all the time due to her idiosyncrasy to the oil and her rash became very troublesome. The urine remained normal but some edema developed; her weight soon rose to 175 and on May 7 her blood pressure was still 140/90 where it remained. Labor began spontaneously on June 7, 1937. A short labor produced a normal 7 pound girl. The placenta came in 10 minutes and showed four marginal deep white infarcts ranging in size from 1 to 3 centimeters in diameter. No her and child did well.

She has had one uneventful pregnancy since.

CASE 4. This woman aged 35 years a primipara was first seen on January 10, 1937. Her last menses had begun on October 4, 1936. At her first visit her blood pressure was 130/75, weight 140 pounds and blood estrogen positive. Accordingly she was at once given Kelly's wheat germ oil. She went along uneventfully until on May 11 it was noticed to be unusually tense the uterine wall was. At that time her weight was 151, her pressure 130/77. There was no albuminuria and the position of the child could not be made out although she was about 7½ lunar months size. She bled about a cupful of bright red blood on May 27, was tender at the right lower aspect of the uterus, and her daily dose of oil was increased to 2 table spoons. There was no more bleeding during the pregnancy, but one never was able to outline the baby as the uterine wall remained too tense. Three days before her labor began on June 5, 1937, her weight was 154, blood pressure 134/79 and the urine clear. She delivered on June 25 with the help of low forceps for a deep transverse arrest, a 6 pound 10 ounce boy. The uterus was tense throughout labor. The placenta seemed completely normal. There was no excess of amniotic fluid. Mother and child did well thereafter.

CASE 5. This woman aged 25 years a primipara menstruated last on July 5, 1937. She was first seen on October 24, 1937, when 3 months pregnant. Her blood estrogen was positive and she was therefore given Kelly's wheat germ oil. Her blood pressure was 112/60 and her weight 121 pounds. After she felt life she stopped taking the oil, unknown to me. She had an uneventful pregnancy except for some sciatica and cholecystitis. On April 25 her weight was 135 pounds, her blood pressure 112/60 and her abdomen was 'huge' according to my notes. She took castor oil on her own initiative on May 1 and felt no life thereafter. Three days later she had a tearing pain worse than a labor and on the 6th she delivered a slightly macerated female child at term. The placenta was normal except for two small, marginal, old white infarcts. The amniotic fluid was pink. Autopsy on the child was uninformative.

She became pregnant again in 1941. Her last period began on December 23. Her blood estrogen was positive again, and once more she was given Kelly's wheat germ oil and warned to continue it until term. Her pregnancy was uneventful except for a recurrence of her sciatica. Her initial weight was 117 pounds, and blood pressure 84/60.

On September 30 these were 141 and 96/66, respectively. There was no albuminuria. Labor was induced on October 5 when she was 6 days over her due date. When the membranes were ruptured the amniotic fluid was blood tinged again. An 8 pound boy was delivered in fine condition after a 5 hour labor. The placenta was normal.

CASE 6. This patient aged 32 years had had two normal pregnancies before. Her last period came on December 31, 1940. She was first seen on May 8, 1941, at which time her blood estrogen was negative, her weight 152 pounds, and blood pressure 114/70. She had an uneventful course until August 2 when she felt as if labor was impending and accordingly was given 1 teaspoon of Kelly's wheat germ oil daily. She then weighed 160, and her blood pressure was 120/70. As she began to have uterine cramps her dosage was soon raised to 2 teaspoons per day. She felt vaguely ill for the next month, her weight on September 25 being 170 pounds and her blood pressure 138/84. Her urine was clear throughout. There was no edema. On October 3 she began labor spontaneously. She ruptured her membranes on the 4th and lost bloody amniotic fluid. Her pains were only moderate and a mid forceps was finally done. The child weighed 9 pounds 7 ounces, had a bilateral hair lip and a severe cleft palate. The shoulders were extremely difficult and the left humerus was fractured in their extraction. The placenta came easily and was normal in appearance.

CASE 7. This woman aged 38 years had had an induced abortion, then two toxic pregnancies proceeding to term, and then another induced abortion by her first marriage. The last of these was in 1936. She was married the second time in 1939. Her last period in this pregnancy began January 28, 1941. She was first seen on May 1 with a weight of 115 pounds and blood pressure of 95/68. Her blood estrogen was positive. She had severe uterine cramps on May 5 and was given Kelly's wheat germ oil at once. She spontaneously ruptured her membranes on June 11 and complained of uterine pains, but did not go into labor. At that time she had a moderate degree of edema and a blood pressure of 125/88. Henceforth she was carried along on at least 1 table spoonful of the oil per day. On June 28 her weight had fallen to 140 pounds, her pressure to 112/76 and there was less edema. The child was active. She was kept in bed for the first 16 days of July because of uterine contractions occurring in spite of 4 table spoons of the oil per day. Afterward her weight was 153, pressure 130/60 and her leg edema was only trivial. She was now taking 3 ounces of oil per day. On October 12 she tried hard to go into labor, had considerable leg and hand edema, had a blood pressure of 126/84 and was given 50 milligrams of ephedrine per day henceforth instead of further wheat germ oil.

On November 1 she went into labor spontaneously with a sudden violent hemorrhage. When sent to hospital she continued to ooze blood slowly. The uterus was too tense to palpate. X-ray films showed a breech presentation with the child in slight flexion. A vaginal examination showed no placenta previa and that the membranes were intact. She was allowed to labor in the Trendelenburg position because otherwise the fetal heart tones slowed down and almost stopped with each contraction of the uterus. An other vaginal examination revealed no cord prolapse that was palpable. The bleeding continued steadily, and considering everything, a low cervical cesarean section was decided upon. The girl delivered weighed 4 pounds 6 ounces and was in poor condition for several days. At operation the placenta was forcibly ejected out of the wound as if the uterus had spit it out. There were huge clots behind it. We had apparently barely beaten a complete detachment. The child died of pneumonia when 5 weeks old, unfortunately. The mother has done well.

**CASE 8.** This woman as physician. He aged 37 years. I had attended her in an uncomplicated pregnancy in 1938. Her last period in this pregnancy began April 3, 1941. She had seventh blood estrogen assay on May 2. As there was considerable vomiting she was given milligrams of atropine per day, and on this there was only slight nausea but no vomiting. Every time the estrogen was discontinued, her vomiting recurred, until she had attained her 4th month.

On September 9 she developed pain and severe tenderness in both lower quadrants of the uterus. She was accordingly given 30 milligrams of ephedrine per day for 3 days, then carried on 9 milligrams per day after the 11th. She bled moderately on the 17th but thereafter the tenderness soon subsided, and she never bled again. On November 5 she reported that the pain had recurred in the right lower quadrant of the uterus. Her blood pressure then was 80/64, and there was no albuminuria. Her dose was raised to 40 milligrams per day. On December 3 strong "labor pains" occurred and lasted throughout the night. Her blood pressure was 70/70, there was no bleeding and no edema, but the uterine tenderness had disappeared. She was raised to 75 milligrams of ephedrine per day which kept her all and symptoms free until December 27, when it was necessary to raise her dose to 100 milligrams per day to relieve her severe pain. She again had freedom from distress until January 6, when it was raised to 5 milligrams per day. This did not give complete relief and she became dizzy. She therefore refused to take more than 50 milligrams thereafter. There was no albuminuria throughout pregnancy. On January 14 her labor began spontaneously was characterized by very severe contractions, and as over 12 hours, she being delivered of a 7 pound, female boy (Her first boy had weighed 8 pounds 6 ounces, be it noted.) The placenta was expelled immediately and displayed a one margin typical area of recent abruption 4 inches in diameter. There was an easy contraction of both mother and child.

**CASE 9.** This woman, aged 26 years, had had no pregnancies before. Her last period began May 24, 1941. She was first seen on July 4, 1941, when her blood estrogen was positive, her weight 54 pounds, her blood pressure 90/60. She was put on Kefly but gained all time but was unable to take it, so was given ephedrine. On the 8th she reported sensation of impending menstruation and that she had had typical menstrual distress nights before. Her dose was therefore raised to 30 milligrams per day.

She was 10 until November 24, at which time her blood pressure had increased to 90/64, her weight 54 pounds, and there was minimal leg edema. For 3 days she had severe cramps as if going into labor. She had dropped her ephedrine to 10 milligrams per day before this, but now reverted to 30 milligrams. On December 6 she bled and had severe pains. She was given 70 milligrams for 3 days, and put to bed. This attack subsided promptly. On the 26th her pressure had risen to 90/60. Her constipation dose was then put to 40 milligrams of ephedrine. She suffered another bout of pain on December 31, so her dose was raised to 50 milligrams. On January 3, she had severe cramps again but no bleeding. There was no albuminuria at any time.

Labor was artificially induced 3 days before her due date and she readily delivered a 4 pound 7 ounce boy after 7 hour labor. The placenta looked normal except for streaks of old black blood on the maternal aspect near one margin. This margin must have separated early in labor or even before.

The milk types of abruptio described above do not always go on to the severest grade because all

high estrin phenomena tend to be self-limiting, probably by anterior pituitary inhibition. If the production of follicle stimulating gonadotrophic hormone in the anterior pituitary is then slowed down, the blood estrogen level probably soon falls to more normal levels—at least in early pregnancy when the placenta is a very secondary hormone source. Hence threatened abortions, threatened miscarriages, threatened premature labors, and mild abruptions tend to subside spontaneously but also to recur often if they may appear to be controlled fairly satisfactorily by the simplest measures, such as bed rest, for example.

Our results could undoubtedly have been improved by the use of larger doses of vitamin E administered earlier in pregnancy. As these were all private patients, economic considerations could not be overlooked, however. The smallest dose was used that seemed likely to relieve symptoms. We used no more until forced to do so. It should be unnecessary nowadays to stress the importance of using a potent preparation of vitamin E. Many products now on the market are far from satisfactory in this respect, however.

It is extremely difficult or impossible to select clinical histories to prove beyond dispute that vitamin E prevents the development of the charred sort of abruptio placentae. If its intended use prevents the appearance of such cases, there is no proof that the patients so treated would otherwise have developed abruptio. If abruptio develops on proper vitamin E therapy, then vitamin E is useless. The cases reported here were held so close to the belief that anyone can still recognize them as abruptions but it is hoped that it is equally clear that some amelioration of their condition can be ascribed fairly to the medication used prophylactically, viz., vitamin E. Better controlled patients might have been described, but the clinical diagnosis would have been criticized sharply. Somewhat analogously one can perhaps suspect from animal experimentation that elevated estrogen levels in the body over a period of years may eventuate in fibroids in women and prostatic hypertrophy in men, but to demonstrate these theories may and dispute is quite another matter and may never be possible. An adequately controlled series of thousands of patients would take years to collect, for the severest abruptions are not encountered every day. Such series was actually being prepared in Canada before the war but that study lapsed when the administration of it was enlisted.

There are probably insuperable difficulties in animal experimentation on this problem, since the placenta of man and mammals differ so greatly.

However, hemorrhage into the amniotic cavity characteristically marks the onset of the termination of pregnancy and the death of the fetuses in vitamin E defective rats (9). This develops on the 12th day, in the second third of such pregnancies—one can scarcely say second trimester, but there may be a human analogy here.

No pregnant uterus should be tender, and the search for tender areas should be as prominent a feature of antenatal care as the supervision of blood pressure and weight. No one would think of administering vitamin E to one of the classical, maximally severe abruptios. How it could help a patient whose placenta is already separated completely or in large part is hard to imagine. But, as has been indicated, the blood estrogen levels of such patients indicate that they display the same estrogen E imbalance as is seen in the milder examples of uterine tenderness and bleeding. One suspects that the classical abruptios are merely the big brothers of the latter who have been allowed to run wild but should all bear the family's surname, abruptio.

The author has been quoted widely in the trade literature on the value of vitamin E in the treatment of abruptio placentae, and does not object if the specific meaning he attaches to the term be kept in mind. Indeed, in order to clarify this very point it was stated in a footnote to one of his papers that the statistics and conclusions in it were not confined to abruptio cases in which the term was used only in the textbook sense of the word.

The writer has given large doses of estrogens to convulsive eclamptics a number of times. On 2 occasions abruptio placentae has quickly ensued

(8) with profuse hemorrhage and severe pains. This is another illustration of the relationship of high estrogen levels to the onset of abruptio placentae in late pregnancy.

#### SUMMARY

1 Abruptio placentae is a late stage of a condition usually recognizable in its early phases by the appearance of small areas of uterine tenderness, small uterine hemorrhages, and evidences of incipient toxemia.

2 It is characterized by a disturbance of the relationship between vitamin E and the estrogens. This can be recognized very early in pregnancy, and on this point hangs the prophylaxis of major catastrophes of this type.

3 The prophylactic value of vitamin E, administered continuously, and in increasing doses as term approaches or frank evidences of toxemia show themselves, is discussed. Illustrative case histories are presented.

4 It is suggested that the best therapy of abruptio placentae is its prevention, and that that is now possible.

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# EDITORIALS

## SURGERY Gynecology and Obstetrics

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OCTOBER, 1942

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### ANNOUNCEMENT

Dr. Frederick Christopher will act for the Editor during the period in which Dr. Davis will serve in the armed forces. Dr. Christopher is a graduate of Johns Hopkins University School of Medicine, associate professor of surgery at Northwestern University Medical School, surgeon in chief of the Evanston Hospital and the author of one and editor of another of the best known texts on surgery.

The policies of this journal will remain unchanged and all communications should be addressed to the Editor as in the past.

### THE SURGICAL DIABETIC

IT is estimated that one and one half to two per cent of the population of the United States are either diabetics or potential diabetics. This represents a great increase in the number of diabetics over the past fifteen years. The increase is not distributed uniformly throughout life or in either

sex but has been shown to occur to a greater extent in children and in women between forty and sixty years of age. In both of these age groups operations are frequently required not only for conditions commonly associated with diabetes but for lesions entirely foreign to the disease. Some metabolists predict that the stress and strain of the present emergency will further increase the number of diabetics.

If the diabetes is adequately controlled by the metabolist it adds little or nothing to the operative risk in operations of election. In emergency cases, particularly those complicated by infection, the operative risk is greatly increased. In the treatment of these cases, the closest co-operation between the medical and surgical departments cannot be overemphasized.

Many diabetics are controlled more easily with protamine zinc insulin. Unfortunately it has proved unsatisfactory to use insulin in this form in the surgical diabetic, as its action may become cumulative at any time and the insulin requirements of the surgical diabetic may diminish very rapidly. For these reasons, patients so treated often went into severe insulin shock. These shocks occurred most frequently after adequate drainage of an infection or in the preoperative treatment of severe hyperthyroidism associated with diabetes. In the light of this experience we have discontinued the use of protamine zinc insulin in the surgical diabetic during the immediate preoperative and postoperative periods and, instead, use either regular or crystalline insulin.

The evaluation of abdominal pain in the diabetic may be both interesting and difficult

We no longer wait until the patient is drowsy or about to go into coma before acidosis is considered. The earlier symptoms and physical findings of acidosis, which may closely simulate those found in acute abdominal conditions, have been clearly demonstrated. Even leucocytosis and fever, so characteristic of the acute abdomen, are associated with acidosis in a high percentage of cases.

When this clinical picture occurs, the surgeon is often called upon to differentiate between acidosis and a surgical abdomen, frequently it is only the urine examination and the subsequent blood sugar and carbon dioxide determination which enables one to arrive at the proper diagnosis. If acidosis is present, it should be treated at once. Under proper treatment the acidosis usually is controlled in four to six hours. Then another abdominal examination should be made to rule out a coexisting abdominal lesion which may require surgical treatment.

In conjunction with Dr. Joseph T. Beardwood, a study was made to evaluate the abdominal pain found in the diabetic and compare it with that which occurred in the nondiabetic. We found that the most severe abdominal pain occurs in diabetic acidosis, in the absence of acidosis, other things being equal, the abdominal pain, due to an underlying pathological process, in the diabetic, is less severe than in the nondiabetic. The last portion of our findings has proved most valuable to us as we had a tendency to underestimate the presence of a surgical lesion in the abdomen of a diabetic, as his symptoms and physical findings did not appear to be severe enough. In our series we now have over fifty diabetics who had lesions in the abdomen associated with pus, and acidosis did not occur in a single case. This is contrary to experience in patients with small collections of pus elsewhere in the body.

Even though acidosis is the most hazardous, infection is the commonest and most serious complication in the surgical diabetic. This is aptly brought to our attention by Dr. E. L. Ehason who pointed out that infection had played a part in 95 per cent of his fatal cases. Since the discovery of the sulfonamides, the various forms of these compounds have been used widely for local applications in infections in the diabetic. Recently the 10 per cent sulfathiazole ointment has been used with excellent results in patients with diabetic gangrene involving only the digits. The number of patients successfully treated by conservative surgery has been increased by the use of this therapeutic agent. This is particularly gratifying when it is considered that these lesions formerly responded very poorly to any form of local therapy. In spite of these favorable reports, experience to date shows that we should not procrastinate in the employment of radical surgery when it is indicated by the local findings and not contraindicated by the patient's general condition. In more extensive processes the local application of sulfanilamide powder, in conjunction with oral administration, has universally proved to be the most effectual. Zinc peroxide was suggested as an antiseptic by Ehas in 1903 but it was not until 1937 that F. L. Meleney and A. B. Johnson, after extensive experimental investigations, advocated its use for the local treatment of infections. Their studies showed that the best results were obtained when it was applied closely, as a creamy suspension in sterile distilled water, to every part of the infected surface and evaporation was prevented by sealing the entire dressing with vaseline or ointment. In chronic processes, complicated by sinus formation, daily irrigation with this preparation has proved most efficacious in the diabetic. The profession welcomes both the sulfonamides and zinc per-

oxide as valuable additions to the armamentarium in the treatment of infections in the diabetic.

A study of the various series of diabetic gangrene, as reported from well organized metabolic services, reveals a great deal of variation in the operative mortality. Further analysis shows that the mortality is in direct proportion to the percentage of cases complicated by severe infection. Operative mortality should not be confused with hospital mortality. This also was pointed out by Dr Eliason in a report of a series of cases of diabetic gangrene: the immediate operative mortality was 3.5 per cent but the hospital mortality rose to 55 per cent in patients who stayed in the hospital for one year.

The highest mortality occurs in the diabetic admitted to the hospital in a very toxic state who has a gangrenous process which will not localize. The investigative work which Dr F. A. Allen has conducted on refrigeration in surgery may lead to a therapeutic measure which will enable us to treat this group with much greater success. In his early reports he emphasized the fact that metabolic activity is lowered when the temperature of tissue has been reduced and suggested that we lower the temperature of the infected parts in patients having a peripheral vascular lesion from which very toxic substances are absorbed. In the past few months he reported the results which were obtained in forty-five cases of gangrene in which the local application of refrigeration had been used.

Our experience with this form of therapy has been limited to only a few cases but the results have been excellent. In carefully selected cases, particularly the very toxic ones just described, this treatment has merit. These early results warrant the further use and evaluation of refrigeration in surgery.

ERICK A. BORTH.

## THE SURGICAL RELIEF OF PAIN

PAIN has lost its useful function when a warning has been given that something is wrong. Treatment of the condition causing pain is the next step. If the lesion is beyond treatment and the pain persists, as in advanced malignant disease, it is equally important that the pain should be relieved.

Pain in cancer is probably not any more severe than pain in many other diseases yet there is a widespread popular opinion that cancer is a most painful disease and leads to a painful death. This belief is, no doubt due to the slow progression and long duration of the terminal painful stage of cancer.

Increased interest in measures for the relief of pain has resulted in the introduction of new procedures and in the extension of the application of others. Some of them are comparatively simple and deserve wider usage. One of the more simple methods is the subarachnoid injection of absolute alcohol introduced by Dogliotti in 1931.

Subarachnoid injection of alcohol for relief of pain is possible because a small quantity of absolute alcohol can be supernatant on the spinal fluid about the pain bearing rootlets. If the patient is properly positioned while the alcohol is slowly injected.

Analysis of the results in 59 patients treated at the University of Minnesota Hospitals by this procedure showed that complete relief was obtained in 61 per cent, partial relief in 1 cent and none at all in 32 per cent. Ten

injected at the University of Minnesota Hospitals, these sequelae have not occurred in the presence of a previously normal spinal cord and cauda equina

Examination of the spinal cords from 5 individuals, who had been given alcohol injections from 3 to 6 months before death, demonstrated that following unilateral injection, there was unilateral patchy demyelination of the posterior rootlets and degeneration of the lateral part of the posterior funiculus of the cord at the site of contact with the alcohol. From these findings, it is concluded that relief from pain is due to partial or complete destruction of the small myelinated and unmyelinated fibers present in the posterior rootlets

Anterolateral cordotomy, or section of the spinothalamic tracts in the upper thoracic segments of the cord, is followed by relief of pain on the contralateral side if the pain is located below the midthoracic region. Rhizotomy of posterior roots can be combined with cordotomy to extend the area of analgesia up to the level of the cordotomy. Anterolateral cordotomy, even when performed on the upper cervical segments for relief of pain in the brachial plexus, does not produce analgesia high enough to be satisfactory. Rhizotomy of the roots of the brachial plexus produces a useless upper extremity anesthetic to all types of sensation. Cordotomy, which leaves intact sensations other than pain and temperature, is ideal for relief of pain in the arm. For this reason operations have recently been devised

for section of the spinothalamic tracts in the medulla and even in the midbrain

Sixteen cordotomies done at the University of Minnesota Hospitals were followed and 13 were found to have been completely relieved of pain. Most of these were for relief of unilateral pain in malignant tumors. Permanent incontinence of urine was not encountered, but to avoid urinary incontinence, which may follow bilateral cordotomy, two patients with bilateral pain were successfully relieved by subarachnoid alcohol injection on one side and cordotomy on the same side for relief of the contralateral pain. This leaves the central and peripheral fibers to the bladder on one side intact, although both central and peripheral fibers on the other side may be injured

Tractotomy of the spinal tract of the trigeminal nerve in the medulla for relief of pain in the face was introduced by Sjoquist in 1938. Since only pain and temperature sensation is conducted through the spinal tract of the trigeminal nerve, the result is ideal, and this operation would supplant rhizotomy for the relief of trigeminal neuralgia were it not for the fact that all pain fibers are not invariably severed, and sequelae, such as ataxia, inco-ordination, and vertigo may follow the procedure. It is, however, satisfactory for relief of pain of malignant disease, and one can also do a rhizotomy of the glossopharyngeal nerve and upper cervical nerves through the same incision, if the pharynx and cervical region are invaded. WILLIAM T PEYTON

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Analysis of the results in 59 patients treated at the University of Minnesota Hospitals by this procedure showed that complete relief was obtained in 61 per cent, partial relief in 27 per cent and no relief in 12 per cent. Ten patients who were relieved completely were followed 6 months or longer and throughout were free of pain. Possible permanent loss of sphincter control or paralysis of the lower extremities is considered to be a contraindication to the injection of subarachnoid alcohol in nonmalignant disease. Yet in 81 patients

injected at the University of Minnesota Hospitals, these sequelae have not occurred in the presence of a previously normal spinal cord and cauda equina

Examination of the spinal cords from 5 individuals, who had been given alcohol injections from 3 to 6 months before death, demonstrated that following unilateral injection, there was unilateral patchy demyelination of the posterior rootlets and degeneration of the lateral part of the posterior funiculus of the cord at the site of contact with the alcohol. From these findings, it is concluded that relief from pain is due to partial or complete destruction of the small myelinated and unmyelinated fibers present in the posterior rootlets

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# THE SURGEON'S LIBRARY

## REVIEWS OF NEW BOOKS

THE need for a brief, comprehensive exposition of a subject long buried in hundreds of papers and texts is amply met by Dr Noel A. Gillespie's excellent monograph. The author's personal acquaintance with most of the modern exponents of tracheal intubation, his own experience both in England and America, and his knowledge of the history of the subject make him well qualified to write on it.

For the anesthesiologist, it offers the most complete review and discussion of endotracheal methods extant. Every phase of the subject is covered, and profusely illustrated. For the specialist in training the book should be a valuable source of guidance, bringing into sharp focus the controversial points and offering sound advice on all of them. The repeated cautions against haste and force in the application of intubation is commendable.

For the surgeon who commands the services of a skilled anesthesiologist, or wishes he could, and particularly for those in the armed forces, this monograph will be of the greatest interest and value. The complexity of the anesthesia problem in many operations makes it imperative that the surgeon have access to such a work as this. Just as important as the solution of the mechanical problems of certain procedures by tracheal intubation, is the improvement in working conditions for the surgeon in cranial, spinal, and upper abdominal operations that the near-perfect airway of endotracheal anesthesia provides. Not so widely appreciated is the added factor of safety for the patient when reflex glottic closure with its attendant apnoea, is forestalled by intubation.

To paraphrase the foreword of Magill, Wertz, and Guedel, "This little book will serve as a guide to improvements in principles and methods which will make endotracheal anesthetics ever more helpful to the surgeon, and a greater protection to his patients."

W. ALLEN COMBES

It is a well bound, nicely printed 500 odd page book. The authors of *The Blood Bank and the Techniques and Therapeutics of Transfusion* have thoroughly covered the field of blood transfusion. There are 4 illustrations. The bibliographical appendices to each chapter appear to be exhaustive in scope.

ENDOTRACHEAL ANESTHESIA. By Noel A. Gillespie, D.M. B.Sc., M.A. (Oxon.). (C. and L. Mackinnon, Women's University of Scotland Press, Ltd.)

THE BLOOD BANK AND THE TECHNIQUES AND THERAPEUTICS OF TRANSFUSION. By Robert L. Magill, M.D., F.R.C.P., and Marshall DeBakey, M.D. M.A., A.C.S. St. Louis, Mo. The C. Mosby Co. 1941.

The chapters dealing with plasma and serum infusions review this relatively recent development very well. In some other sections of the book a clear distinction between serum and plasma is not made.

Particularly well done is the clear and concise account of recent experimental work in all sections of the book.

The reviewer believes that the authors are mistaken in their contention that fresh citrate transfusions are in any way inferior to those of unmodified blood.

For laboratories, hospitals, or those interested in blood transfusion the book is accurate.

THOMAS C. DIXON

THE third revised edition of what the author modestly calls "hand book" is prepared by the statement "To anyone interested in therapeutics it must seem that the few years since the second edition of this book appeared has been the most exciting since the recollection of most of us. Because this statement is undoubtedly correct, this new edition of a particularly fine book is particularly appropriate at this time."

The book has been completely revised and brought up to date in all respect with special emphasis on the section dealing with drugs and organ extract used in ophthalmology. This section now contains

a brief readily understandable exposition on the mode of action of the sympathomimetic and parasympathomimetic drugs. Also, and more important, it deals to considerable length with the effect of the sulfonamide derivatives on gonorrheal ophthalmia and trachoma, giving specific dosages and modes of administration. The section on vitamins has been brought up to date by an adequate discussion of therapeutic indications.

It is to be regretted that the author devotes so much space to the treatment by diodes of incipient lens changes, a form of therapy which has long since been discarded by leaders in the field of ophthalmology as being obsolete.

The book retains the same format used in previous editions with many of the same illustrations, most of which are excellent. This edition fills a definite need and will be welcomed by ophthalmologists, and it is hoped that the author will continue to offer periodic revisions bringing the material up to date as the occasion offers.

D. B. TRIVETT

HAND-BOOK OF Ocular THERAPEUTICS. By Sanford Collins, M.D. F.A.C.S. 3d ed. Philadelphia, Lea & Febiger 1941.

QUITE frequently medical students, postgraduate students, and practicing physicians whose field does not include neurological surgery desire a comprehensive treatise on the subject. It is possible to compile from the literature a comprehensive survey of neurological surgery but a single volume containing concise, complete discussions on neurological diagnoses, craniocerebral injuries, intracranial tumors, intracranial abscesses, surgical lesions of the cranial nerves, injuries and tumors of the spinal cord, and injuries to the peripheral nerves in conjunction with surgery of the autonomic nervous system, including hypertension, is very difficult to find. In Doctor Davis's monograph,<sup>1</sup> the second edition of which has just been published, one is able to find just such a book and it fulfills a much needed place on the library shelves of many busy physicians who may turn to it in order to keep up with what is being done at the present time for many neurological lesions.

The book is well written and contains excellent photographs, diagrams, and photomicrographs. The size of the volume is convenient and it is attractively bound in buckram.

In the preface the author states definitely that "This book makes no pretense at including an exhaustive treatise upon each subject considered. The purpose has been to give to the practitioner of medicine and to the medical student easily assimilable facts which will aid them in getting a more accurate concept of neurological surgery to the end that their patients will receive accurate and sound advice."

WINCHELL MCK CRAIG

THE reprinting of Dr. Ferguson's excellent book *Röntgen Diagnosis of the Extremities and Spine*<sup>2</sup> has afforded him an opportunity for its enlargement. The additional material includes a new chapter devoted to the lame back. This section approximates the detailed exposition offered in the lame back exhibit at the meetings of the American Medical Association.

The author has drawn liberally from his broad experience in one of the largest orthopedic hospitals. The subject matter is presented in concise and logical manner. The opening chapter on the analysis of roentgenograms must be read carefully if the reader is to understand the definitive roentgenologic nomenclature used by the author. These technical roentgenologic terms appear in bold faced type throughout the text. Pertinent clinical information is presented at the end of each chapter in short case histories. Frequent references at the foot of each page indicate the illustrations depicting the roentgen feature under discussion. The subject matter is profusely illustrated. The reproductions are in the positive phase rather than in the form of the original negatives.

This book is not the type which can be read

NEUROLOGICAL SURGERY. By Loyal Davis M.S. M.D. Ph.D. D.Sc. (Hon.) 2d ed. Philadelphia Lea & Febiger 1942.  
RÖNTGEN DIAGNOSIS OF THE EXTREMITIES AND SPINE. By Albert B. Ferguson M.D. Annals of Roentgenology Vol. 17. New York: Paul B. Hoeber Inc. 1941.

lightly. As mentioned previously, a careful perusal of the introduction is necessary if the reader is to take full advantage of the excellent subject matter as presented by the author. The arrangement of the text consists of a tabulation and discussion of roentgen features rather than a discussion of diseases. References for the various diseases, their outstanding features and the definitive technical terms used in description are offered in an extensive but workable index.

The field of roentgenology of the spine and extremities is presented in a concise organized manner. Students and practitioners, particularly roentgenologists and diagnosticians dealing with bones and joints, will find this book to be very useful as a reference work and as a guide in the differential diagnosis of injuries, diseases and deformities of the spine and extremities.

EARL E. BARTH

THE monograph by Dieckmann<sup>3</sup> is the most comprehensive treatise on toxemias of pregnancy that has been published. It is a volume of 500 pages, containing 50 illustrations and 3 colored plates. In the preface Dieckmann states that he had a two fold objective in the compilation of this work, one to acquaint the obstetrician with some of the recent contributions on physiology pertaining to obstetrics, and the other to acquaint the investigator, untrained in obstetrics, with some of the physiology and pathology of obstetrics.

The book is divided into 6 sections, each of which deals with certain phases of the subject. The first section considers the classification, incidence, and pathology of toxemias. The second section under the heading of normal and abnormal physiology deals with the physicochemical determinations, blood pressure, renal physiology, the liver, the ocular system, the placenta, and the endocrines. Section three deals with the etiology of eclampsia and all factors pertaining to or influencing this condition are discussed. Sections four and five consider the clinical aspects and the treatment of toxemias respectively while the maternal and fetal prognoses are discussed in the last section. Following each chapter, a complete bibliography is found.

The author of this volume has done a tremendous amount of original research in the field of toxemias of pregnancy and is thoroughly familiar with the work of all other investigators in this field. He has presented in this work the results of his own investigations and the conclusions drawn therefrom, the results of other investigators and their conclusions are liberally quoted. Obviously the reader will find himself familiar with much of the material which has been drawn upon in the compilation of this book, for it is in fact a condensed review of all the worth while material produced in recent years on this subject. This volume should be read by everyone interested in the subject of toxemias and retained as a reference thereafter.

CHESTER C. DOHERTY

\*THE TOXEMIAS OF PREGNANCY. By William J. Dieckmann M.D. St. Louis: The C. V. Mosby Co. 1941.



**WHEN** *Diagnostic Roentgenology* was published 5 years ago the editor and publisher assured the purchaser that additional up-to-date material would be issued at regular intervals. The first renewal service in 1933 consisted of 355 additional text pages and 250 new illustrations. The second renewal service the publishers are supplying more than 600 additional pages. The addition of this material as well as revised and enlarged index, table of contents and list of contributors has necessitated a second volume and a new binder (Volume II) is furnished without charge.

The additional material includes five new chapters. The Roentgen Diagnosis of Fractures and Dislocations, by L. Henry Garland. Roentgen Diagnosis in Infants and Children, by John Caffey. Soft Tissue Roentgenography, by James R. Lingley and William J. Elliott. Laminography, by Sherman Moore. Angiography, by John D. Camp and Edgar V. Allen. An addendum to his chapter on Radiology of the Chest has been prepared by Coleman B. Rubin. New material has been added to the chapter on the Use of the Roentgen-Ray in Obstetrics. The section on Roentgen-Ray Diagnosis of Diseases of the Skull and Intracranial Contents has been completely revised by Dr. Cornelius G. Dyke and now comprises 3 pages with 316 illustrations.

The addition of all this new material greatly enhances the value of this already well established contribution. The 94 two-volume edition of *Diagnostic Roentgenology* represents the most complete and comprehensive presentation of the subject of roentgen diagnosis available in this country. It is recommended not only to the roentgenologist but will be a valuable aid in the diagnostic work of all practitioners.

ELIAS F. BAUME.

**THE** that of the book, *Clinical Roentgenology of Pregnancy* intended that it should not only serve to acquaint the reader with the roentgen study of pregnancy but above all enable him to do the work himself. Separate chapters are devoted to general discussion of the use of x-ray in pregnancy, positioning of the patient, and technique of ray exposures, x-ray pelvimetry and cephalometry computations, the pelvic shape and its measurements, the fetus and pelvis, roentgen visualization of the soft tissues in pregnancy and case reports. The author has drawn liberally from his extensive experience in this field, consequently considerable space is given to a discussion of x-ray visualization of the soft tissues in pregnancy. His own methods of ray pelvimetry and cephalometry are described. Distortion of the various pelvic and cephalic diameters as measured on the films are corrected by the use of either a chart which is reproduced in the book or slide rule devised by the author. Methods other

than these are discussed for measuring the pelvis and the fetus are discussed briefly in the first chapter. The volume contains 19 illustrations, including reproductions of roentgenograms, line drawings and photographs of equipment. The illustrations which accompany the case reports are reproduced in scale and are accompanied by the author's measurements and comments, thus providing the reader an opportunity to make his own measurements. Reproductions and line drawings enhance greatly the value of the discussion of the roentgen localization of the soft tissues in pregnancy.

This volume provides a quick general outline of pelvimetry for the method described. It can be recommended to the physician who is interested in roentgenography as it pertains to obstetrics.

ELIAS F. BAUME.

**THOUGH** rather brief Padgett's monograph on *SKIN GRAFTS* is devoted to the entire methodology of skin transplantation. The historical and histological sections and those on preoperative and postoperative treatment are generally inadequate as compared to other recent, more detailed articles on the subject.

The author fails to stress the importance of careful aseptic care of the large open granulating surfaces in either the preoperative or postoperative treatment and this omission might lead to sepsis or cancer technique by the beginner.

There is nothing in the text to substantiate the statements made on the jacket of the book regarding "No longer need the physician hesitate as to his dexterity in removing the proper graft. Nor is there further need to fear the failure of take."

The book contains no new principle but is devoted to explaining a new mechanical device for the removal of skin for grafting.

HARVEY LAMM.

**THE** book, *Roentgen Treatment of Eruptions* is primarily a presentation, in book form, of the three cases of gas gangrene, peritonitis, and pneumonia treated with x-rays. A few additional photographs are included to mention the use of ray therapy in erysipelas, boils, Ludwig's angina, ray puncture, impetigo, acne, plaques, ulcers, abscesses, meningitis, and other conditions. The discussions and literature citations on the latter group are very incomplete and misleading.

The term "gas gangrene" is very badly defined but the definition serves adequately for subsequent exorbitant claims concerning the value of ray therapy. Reference is repeatedly made to the "antitoxic" value of x-rays which has no factual basis. The author likewise emphasizes symbolism in the etiology of gas gangrene which also is without experimental proof.

MRS. GRANTON, FRANK, PETERSON, and FREDERICKSON, 1937, by Earl John Padgett, M.D., A.C.S., Springfield, Ill. and St. Louis, Mo. Charles C. Thomas, 1941.  
 "Roentgen Treatment of Eruptions," by James F. Keane, M.D., C.M., and D. Arnold Smith, M.D., Chicago, Ill. The Year Book Publishers, Inc., 1941.

*DIAGNOSTIC ROENTGENOLOGY*. Edited by Ross Golden, M.D. 1941. Renowned Pages, Volume 11. New York: Thomas Nelson & Sons, 1941.

*CLINICAL ROENTGENOLOGY OF PREGNANCY*. By William Shaw, M.D. Springfield, Ill. and Baltimore, Md. Charles C. Thomas, 1942.

activities of the College and officially announce the approved lists of hospitals, cancer clinics, hospitals approved for graduate training in surgery and the surgical specialties, medical services in industry, and medical motion pictures

#### PRESIDENTIAL MEETING AND CONVOCATION

The impressive and colorful ceremony surrounding the reception into fellowship of the 1942 class of initiates, the conferring of honorary fellowships upon distinguished surgeons, and the inauguration of officers of the College for the 1942-1943 term will take place on Tuesday evening in the Music Hall of the Public Auditorium. Distinguished surgeons from foreign countries attending the Congress will be introduced, and the presidential address by the retiring president, Dr W Edward Gallie, of Toronto, will follow.

Appearing on the program will be the Surgeons General of the Army, Navy, and Public Health Service, and the Chief Medical Officer of the Office of Civilian Defense. The final feature of the evening's program will be the presentation of the 1942 medical records prize award to that candidate for fellowship who has, in the opinion of the judges, presented the most acceptable set of case records and the honor list of candidates who were awarded honorable mention for their case records. The prize award of \$500 is made by SURGERY, GYNECOLOGY AND OBSTETRICS, to be invested in the name of the successful candidate for a life membership in the College.

#### PANEL DISCUSSIONS ON WAR SURGERY

Concentration of interest on various phases of surgery as related to the war effort impelled the Board of Regents to change from the usual plan of holding several panel discussions simultaneously on various specialized subjects to a program of master panels that deal with the important phases of war surgery, to be held consecutively. Similar panels proved to be most interesting and beneficial during the "War Sessions" held by the College in several large cities during the early part of the year.

This plan makes it possible for surgeons to attend all the panels. Ample accommodations are afforded in the Music Hall of the Public Auditorium for the large audiences which will be attracted by these master panel discussions scheduled to be held each afternoon, Tuesday through Friday, and on Wednesday, Thursday and Friday evening. The leaders and collaborators in the panel discussions will include surgeons in active military service and eminent surgeons from civil life. In the following pages there appears

#### EXECUTIVE COMMITTEE

Thomas E Jones, Chairman	C Lee Graber
John W Holloway, Secretary	John F Hannibal
Arthur H Bill	Carl H Lenhart
Abram B Bruner	Thomas P Shupe
John F Corrigan	Abraham Straus
Clarence W Engler	Oliver A Weber
Samuel O Freedlander	Theodore A Willis

#### HOSPITALS AND REPRESENTATIVES

City Hospital—Samuel O Freedlander  
Cleveland Clinic Hospital—Robert S Dinsmore  
Evangelical Deaconess Hospital—Oliver A Weber  
Fairview Park Hospital—F H J Heyse  
Glenville Hospital—Jacob E Tuckerman  
Grace Hospital—A L Biddinger  
Huron Road Hospital—Benjamin B Kimmel  
Lakeside Hospital—Frederick R Mautz  
Lakewood Hospital—C Lee Graber  
Lutheran Hospital—Frank S Gibson  
Maternity Hospital—W R Barney  
Mount Sinai Hospital—Abraham Strauss  
Polyclinic Hospital—A I Spurney  
St Alexis Hospital—John F Corrigan  
St Ann's Maternity Hospital—E P Monaghan  
St John's Hospital—Irrell T Gallagher  
St Luke's Hospital—Russell S McGinnis  
St Vincent's Charity Hospital—Oliver A Weber  
United States Marine Hospital—S A DeMartini  
Woman's Hospital—B B Colvin

a detailed program for these master panel discussions, indicating the subjects to be presented and the leading participants therein.

In addition to the panel discussions on Wednesday evening, Captain Frederick R Hook, MC, USN, will deliver the annual oration on surgery—"Wounds in Combat."

#### FORUM ON FUNDAMENTAL SURGICAL PROBLEMS

At the 1941 Clinical Congress in Boston, the "Forum on Fundamental Surgical Problems" achieved a great success, and will again have an important place on the program for the Cleveland session. Under the chairmanship of Dr Owen H Waugensteen, of the University of Minnesota, a committee is preparing the program to be presented on Wednesday, Thursday, and Friday mornings providing an opportunity for the younger men representing various university departments of surgery, clinics, and hospitals, to present before a large surgical meeting the important results of their clinical and experimental research work.

Dr Waugensteen comments as follows on the purpose of the program for the forum:

This portion of the program, instituted by the Board of Regents to provide an opportunity for the presentation of the results of original clinical and experimental research, established itself in its first session a year ago and appears to have satisfied its task. It afforded a large surgical audience a

# CLINICAL CONGRESS OF AMERICAN COLLEGE OF SURGEONS

W. EDWARD GALLIE, Toronto, *President*

IRVIN ABELL, Louisville, *President Elect*

*Committee on Arrangements*

THOMAS E. JONES, *Chairman* JOHN W. HOLLOWAY, *Secretary*

## 1942 CLINICAL CONGRESS IN CLEVELAND—A WAR SESSION

UNDER the direction of the Board of Regents, a four-day program is being developed for the thirty-second annual Clinical Congress, to be held in Cleveland, November 17 to 20, with headquarters at the Cleveland Public Auditorium. This fine large building with its Arena, Music Hall, Little Theater Ballroom, and other large halls provides exceptional facilities, so that all activities of the Congress, excepting the clinical program, will be housed in that building. The program of the Congress in general will be based upon the many medical and surgical problems arising out of the prosecution of an all-out effort to win the war emphasizing the needs of the rapidly expanding medical services of the Army and Navy with consideration of the special problems related to the increasing activities for civilian defense.

### CLINICAL PROGRAM

The surgeons of Cleveland have organized, with Dr. Thomas E. Jones as chairman, and Dr. John W. Holloway as secretary of the Committee on Arrangements. In the following pages there is presented a preliminary clinical program as prepared by the committee, consisting of operative clinics and demonstrations that will provide a comprehensive showing of their clinical activities in all departments of surgery at Western Reserve University School of Medicine and the approved hospitals of Cleveland. Under the leadership of this committee representative of the interests of all surgical specialties, complete and varied program is assured for the 1942 Congress. It will be noted that the program includes the presentation of the latest advances in diagnostic methods, operative procedures, pre- and postoperative care of the surgical patient. Clinics and demonstrations will be held in the hospitals on the afternoon

of Tuesday November 17 and the mornings and afternoons of the succeeding days.

The final clinical program to be presented at the Cleveland hospitals will be arranged to include a wide variety of subjects in general surgery, obstetrics and gynecology, fractures and other traumas, orthopedic surgery, urological surgery, neurosurgery, thoracic surgery, ophthalmology and otolaryngology. The presentations at the hospitals under these classifications will be so correlated that the visiting surgeon may devote his time to those clinics dealing with the special subjects in which he is most interested. A complete detailed clinical program for each day will be posted in the form of bulletins at headquarters during the afternoon of the preceding day and distributed in printed form each morning.

### GENERAL ASSEMBLY

The Clinical Congress will open with a general assembly at headquarters at 9:30 on Tuesday morning. From the program, which appears on another page, it will be noted that the speakers at this assembly are leading figures in the war, those medical activities. The Surgeons General of the Army, Navy and Public Health Service, the chief of the medical division of the Office of Civilian Defense and the chairman of the Directing Board of the Procurement and Assignment Service will be present to discuss the activities of their respective branches of service. The president of the American College of Surgeons, Dr. W. Edward Gallie of Toronto, will speak on "Medical and Hospital Service in the War" and will preside at this assembly. The chairman of the Board of Regents, Dr. Irvin Abell, of Louisville, will review what has been accomplished by the College in the field of hospital standardization during 25 years, and will report upon the field

## CANCER CONFERENCE

A cancer conference, sponsored by the Cancer Committee of the College, will be held on Thursday morning. A report on an experiment to control cancer of the uterus will be made. Some of the surgical problems connected with pulmonary, abdominal, and rectal carcinoma will be presented by pioneers in this work. Lessons learned from the experiences with cancer clinics by the College will be presented, as well as a report on further 5-year cures of cancer. This cancer symposium will be of interest not only to those who are interested in organization for cancer control, but also to surgeons under whose immediate care cancer cases susceptible of surgical treatment may come.

## HOSPITAL STANDARDIZATION CONFERENCE

Major emphasis in the program for the twenty-fifth annual Hospital Standardization Conference will be upon wartime and postwar problems. Those in attendance will participate in the opening session of the Clinical Congress at 9:30 Tuesday morning in the Cleveland Public Auditorium, which has been mentioned previously under the heading of "General Assembly," and which will be addressed by the Surgeons General of the Army, Navy, and Public Health Service, and other well-known leaders in wartime medical activities. The 1942 list of approved hospitals, hospitals approved for graduate training in surgery, and approved cancer clinics, will be announced at this session by the Chairman of the Board of Regents of the College, Dr. Irvin Abell, who will also review the record of accomplishments of the College in the hospital field during twenty-five years.

Emphasis will be placed in the hospital conference on the more scientific and technical phases of hospital care. In order to cope with the problems created by wartime shortages, the present-day administrator must have knowledge of the newer ideas and procedures that are being developed in war medicine and surgery. Surgeons, surgical specialists, pathologists, and anesthetists will, in a series of panel discussions, present discussions of the newer therapies in civilian and military practice, stressing the administrative or service significance. The obvious desirability of complete co-operation by the administrative staff with the medical staff in the emergencies which may be expected in a war period makes this part of the program of outstanding interest to both medical and administrative personnel. Reference is made for details to the hospital program appearing on another page.

Special attention is called to the Wednesday evening conference on "Civilian Defense As Related To Hospitals," which will be conducted by Dr. George Baehr. This will be followed by a round table discussion in which opportunity will be provided for obtaining authoritative answers to questions that have arisen in connection with the part of the hospital in civilian defense.

The breakfast conference on "Inter-American Hospital Relations" on Wednesday morning should attract a large attendance in view of the paramount importance of cementing medical and hospital ties between the Americas as a vital part of the "Good Neighbor" policy. A breakfast conference is also planned, it will be noted, for Thursday morning, on "Hospital Public Relations," in which three of the speakers will be representatives of newspapers, with a fourth presenting the hospital point of view.

The program for the final day, Friday, opens with a large general panel round table conference on "War and Postwar Problems of Hospitals." The war has brought many new problems to confront our hospitals in rendering service to the patient. These problems are in the main most difficult to solve and in fact some of them appear insurmountable. The only way in which they can be approached with hope of a solution is to regard each one as a challenge to supreme effort in the all-out program to win the war. The hospital is contributing personnel to the military services, but it must not let these losses weaken the health and defense of its community. In this conference way and means of overcoming the difficulties of maintaining adequate service in all departments of the hospital which contribute to the care of the patient will be considered.

In the afternoon of the final day there will be opportunity for choice between attending the panel discussion on "Evacuation and Hospitalization of Wounded in Theaters of Operation," the conference on "Making and Evaluating Medical Motion Pictures," or participating in the study tour of local hospitals.

The program throughout has been planned to interest all types of hospital personnel who are concerned with directing the course of hospital work through the critical war period, and of course this includes the important group that serve as members of governing boards.

## SCIENTIFIC EXHIBITS

Exhibits portraying the activities of the American College of Surgeons will be on display, and other national organizations have been offered an opportunity to present exhibits showing

the opportunity to become acquainted with the work of many productive clinical and experimental investigators through the medium of the concise presentation at the same time it accorded a number of young, well-trained surgeons their first opportunity of bearing before a national surgical organization. In the past, not infrequently young surgeons have found it necessary to have their work receive recognition before another audience before surgeons could deign to hear them. The late William J. Mayo felt keenly that the wisdom of age and experience should be exchanged freely with the enthusiasm of youth, and that both old and young would benefit by the barrier of the main, the most original contributions to surgery are made by young men. For the improvement of surgery as well as the enlightenment of surgeons with greying hair and other eloquent marks of advancing years it is important that young, productive workers in surgery be provided an opportunity early in their careers for active participation in surgical gatherings—before the cares of time dampen their enthusiasm.

Furthermore surgeons are not long the best company for one another. Surgeons need the stabilizing influence which comes from association with workers in other fields of medicine. Hence programs constituted year after year only from the membership of a like-minded group of men such as surgeons are likely to reveal traces of truth deficiencies. A group of medical men can suffer isolation long with out exhibiting unmistakable evidences of it. Recognizing the great importance to surgeons of the life-giving spirit and vital sustenance to be gained through association with fellow workers in the broad domain of medicine the Board of Regents of the American College of Surgeons has authorized inclusion of papers of general interest to surgeons, emanating from the pens of investigators in other provinces of medicine. The interests of the membership of a large organization are served best by provision for the most original and stimulating papers that come within the scope of concern of its auditors, and that are pertinent to the occasion. It is unimportant whether the papers come from within the membership or by invitation to non-members.

It is the professed purpose of the surgical forum to attempt to bring before its assembly each year the best that is new in surgery. This venture has had the hearty support of the professors of surgery in the medical schools of the American universities. The interest manifested in the first program presented at last year's meeting suggests that the surgical forum will come to be an integral part of the Clinical Congress of the American College of Surgeons. If there can be realized the endeavor to bring annually to the Clinical Congress the best creative thought and original achievement in American surgery the surgical forum will continue to perform a useful function. The surgical forum might well become the federated surgical society of America embracing, as does its preclinical prototype a number of related specialties. There is a great need for

more intimate co-ordination between the scientific programs of the various surgical specialties such as anesthesiology, neurosurgery, orthopedics, plastic surgery, thoracic surgery, urologic surgery and their parent mother general surgery. The surgical forum is serving to focus important notice upon a rather large group of young men in universities who are making worthwhile contributions to the progress of surgery. The sponsors of the forum earnestly hope that this new venture will afford producers, men both young and old, through the whole range of surgery, a useful outlet for the announcement of the results of their investigations. An annual program, embracing new accomplishments in the several provinces of surgery and the most original thought, will be attractive and reciprocally advantageous to participant and auditor alike. Such a program has in it the cement substance to unify by a common bond the progressive spirit of the best in American surgery and its specialties. Realization of such an objective would infuse into our hands more of the scientific outlook and less of the indelible impress upon American surgery for the better.

This year our country is at war. The staffs of our surgical clinics have been depleted and everyone's chief concern is focused on the war and its successful prosecution. Yet it is important that scientific meetings continue for the purpose of instruction and for the announcement of new found knowledge.

In the selection of presentations at the surgical forum the committee is guided by originality of thought and interest suggested in the abstracts submitted by the authors. Each speaker will be allowed ten minutes for his presentation. Anyone interested in participating in the program is invited to send at once the title of his presentation, accompanied by an abstract of not more than 300 words, to the Surgical Forum, American College of Surgeons, 50 East Lake Street, Chicago.

#### SURGERY OF THE EYE, EAR, NOSE AND THROAT

The general program of the Congress includes many features of special interest to those surgeons whose practice is limited to ophthalmology and otorhinolaryngology. Operative clinics and demonstrations will be given daily at the hospitals. Programs for a series of clinical conferences on Wednesday, Thursday and Friday mornings and panel discussions on Wednesday, Thursday and Friday evenings at headquarters will be found in the following pages. At the morning conferences subjects of timely interest to specialists in these fields will be discussed in small groups. Outstanding specialists will lead the discussions and opportunity will be provided for questions and participation. Preceding each morning and evening session selected motion picture films related to special subjects in these fields will be exhibited.

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## SCIENTIFIC EXHIBITS

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phases of their work. Also there will be individual exhibits demonstrating some phases of fracture work, bone sarcoma, and refrigeration anesthesia. The Office of Civilian Defense will have an exhibit portraying the operations of an emergency medical service particularly the treatment of burns, and work in connection with blood plasma banks.

#### RAILROAD TRANSPORTATION

While no special rates have been authorized for the 1942 Clinical Congress in Cleveland by the railroads of the United States and Canada round trip tickets to Cleveland, sold at less than double the regular one way fare, will be available from all points in the United States and Canada. No certificates are required. Return limit and stopover privileges on such round-trip tickets are liberal but are not uniform in all sections of the country. Surgeons planning to attend the Congress should consult local ticket agents in advance of the meeting for complete information as to fares, routes, stopover privileges, etc. It is important that pullman reservations be made at the earliest possible date as the railroads are handling a large amount of passenger traffic. The suggestion is made that travellers will find daytime trains within an area of 400 to 500 miles from Cleveland are less crowded than night trains.

#### SURGICAL MOTION PICTURES

Daily presentation at headquarters of a large and varied program of surgical motion pictures is planned. The latest available films, on a wide variety of subjects of interest to the surgeon, will be included. Both sound and silent standard and color films that have been approved by the Committee on Medical Motion Pictures will be shown.

#### ADVANCE REGISTRATION AND REGISTRATION FEES

The hospitals and medical school of Cleveland afford accommodations for a large number of visiting surgeons, but attendance must be limited at the clinics to the number that can be comfortably accommodated. It is expected, therefore, that surgeons who wish to attend the Congress will register in advance. As in previous years, admission to clinics and demonstrations in the hospitals and to certain of the scientific meetings at headquarters will be controlled by means of tickets issued to the visiting surgeons on application at the registration desk. This plan provides for the distribution of visitors and helps to insure against overcrowding. Surgeons are urged to cooperate in making the clinic ticket plan a success.

In accordance with resolution adopted by the

Board of Regents, fellows of the College whose dues are paid to December 31, 1941 initiates of the class of 1942 and fellows in military service will not be required to pay a registration fee for the 1942 Clinical Congress. For endorsed junior candidates the fee is \$5.00. Surgeons, not fellows, who attend as invited guests of the College, will pay a registration fee of \$10.00.

For purposes of identification at the registration desk, fellows should present their fellowship cards. Those surgeons who pay the registration fee in advance will receive a formal receipt which they will exchange for a general admission card upon presentation at the registration desk in the Cleveland Public Auditorium.

#### HEADQUARTERS—TECHNICAL EXHIBITION

Headquarters for the Congress will be established at the Public Auditorium, which affords unusual facilities for accommodating the Congress. All activities except the clinics at the hospitals will be held in this building.

The Technical Exhibition, together with the registration and clinic ticket desk, will be located in the arena on the main floor of the Auditorium. The daily clinical program will be posted there, in the form of bulletins. Leading manufacturers of surgical instruments and supplies, sutures, drawings, pharmaceuticals, operating room equipment, x-ray apparatus and hospital equipment of all kinds, as well as publishers of medical books will be represented in the exhibition. An opportunity for careful inspection of the latest products of all those industries which are aiding the work of the surgeon and the hospital, will be provided for the visiting surgeons and hospital personnel.

#### CLEVELAND HOTELS AND THEIR RATES

Cleveland has many first-class hotels, several within walking distance of the Public Auditorium, providing ample hotel facilities at reasonable rates. It is suggested that reservation of hotel accommodations be made at an early date.

	Minimum rate which hotel guarantees	
	Single	Double
Alborton, Chester at East 7th St.	\$ 30	\$ 40
Auditorium, St. Clair & East 4th St.	2.00	4.00
Carter Prospect & East 9th St.	3.00	4.50
Cleveland, Public Square	3.00	4.50
Hollenden, 6 Superior A. & E.	3.00	4.50
Lake Shore, 506 Edgewater A. E.	3.50	5.00
New Amsterdam, Euclid at East 2nd St.	.00	3.00
Olmsted, Superior at East 9th St.	.00	4.00
Sovereign, East Blvd. and East 10th St.	3.00	4.00
Scatter, Euclid at East 7th St.	3.00	4.50
Tudor Arms, 6000 Carnegie Ave.	3.50	5.00
Wade Park Manor Park Lane at East 7th St.	3.50	5.00

## ANNUAL HOSPITAL STANDARDIZATION CONFERENCE

*Tuesday, 9 30 a m —Music Hall, Public Auditorium*

Opening Session of War Congress—General Assembly  
W EDWARD GALLIE, M D, Toronto, President, American College of Surgeons, presiding

Presentation of Report of Field Activities of the American College of Surgeons for 1942, and Summarization of a Quarter Century of Hospital Standardization IRVIN ABELL, M D, Louisville, Chairman, Board of Regents, American College of Surgeons

Medical and Hospital Service in Canada During the War  
W EDWARD GALLIE, M D, Toronto

United States Army Medical Service in the War Major General JAMES C MAGEE, Washington, Surgeon General, United States Army

United States Naval Medical Service in the War Rear Admiral ROSS T MCINTIRE, Washington, Surgeon General, United States Navy

The Health of the Nation in Wartime THOMAS PARRAN, M D, Washington, Surgeon General, United States Public Health Service

Civilian Defense in Its Relation to Medical and Hospital Service GEORGE BAEHR, M D, Washington, Chief Medical Officer, United States Office of Civilian Defense

The Procurement and Assignment Service FRANK H LAHEY, M D, Boston, Chairman, Directing Board, Procurement and Assignment Service

*Tuesday, 2 00 p m —Little Theater, Public Auditorium*

Rev Monsignor MAURICE F GRIFFIN, Cleveland, presiding

Maintaining Our Voluntary Hospital System During and After the War Rev Monsignor MAURICE F GRIFFIN, Cleveland

Adjusting Hospital Administration and Services to War and Postwar Conditions JAMES A HAMILTON, New Haven, Conn

Meeting the Medical Personnel Needs of the Armed Forces and Maintaining Adequate Medical Services in Civilian Hospitals FRANK H LAHEY, M D, Boston

Meeting the Nursing Needs of the Armed Forces and Maintaining Adequate Nursing Services in Civilian Hospitals JULIA C STIMSON, R N, New York

Maintaining Medical and Nursing Services in Canadian Hospitals During the War G HARVEY AGNEW, M D, Toronto

*Wednesday, 7 45 a m —Staller Hotel*

Breakfast Conference on Inter-American Hospital Relations W FRANKLIN WOOD, M D, Waverley, Mass, presiding

Plans for the Promotion of Inter-American Relations FELIX LAMELA, San Juan, Puerto Rico

General Discussion Opened by DONALD C SWEETZER, M D, Philadelphia

*Wednesday, 9 30 a m —Little Theater, Public Auditorium*

LEE S LANPHER, Cleveland, presiding

Panel Discussions  
The Requirements, Organization, and Operation of Blood and Plasma Banks SIDNEY O LEVINSON, M D, Chicago

Managing the Intern Problem Under the Accelerated Medical Education Program C D CREEVY, M D, Minneapolis

The Problem of Maintaining Adequate Supplies and Equipment for Civilian Hospitals During the War EVERETT W JONES, Washington

The Problem of Maintaining Adequate Medical Records in Civilian Hospitals During the War, and Its Solution CHRISTOPHER G PARNALL, M D, Rochester, N Y

*Wednesday, 2 00 p m —Little Theater, Public Auditorium*  
Panel Discussions

The Responsibility of the Administrative Staff of the Hospital in Dealing with Common Emergency Procedures Conducted by FRED G CARTER, M D, Cleveland

Posttonsillectomy Hemorrhage CARL H McCASKEY, M D, Indianapolis

Respiratory Obstruction Requiring Intubation or Emergency Tracheotomy HORACE E MITCHELL, M D, Cleveland

Sudden Collapse of Postoperative Patient Due to Pulmonary Embolus MARSHALL DAVISON, M D, Chicago

Emergencies Arising During the Administration of Anesthesia RALPH T KNIGHT, M D, Minneapolis

Acute Cardiac Attack, Coronary Thrombosis ROY W SCOTT, M D, Cleveland

Sudden Collapse on Operating Table GILSON C ENGEL, M D, Philadelphia

Hemorrhage—Acute and Postpartum RALPH E CAMPBELL, M D, Madison, Wis

Acute Poisoning CHARLES W MYERS, M D, Indianapolis

*Wednesday, 8 00 p m —Little Theater, Public Auditorium*

Special Conference on Civilian Defense as Related to Hospitals Conducted by GEORGE BAEHR, M D, Washington

General Statement from the Office of Civilian Defense GEORGE BAEHR, M D, Washington

Relation of the Medical Officer, Civilian Defense Region, to the Hospital JOHN S COULTER, M D, Chicago

Arrangements of the United States Public Health Service and the Office of Civilian Defense for Providing and Financing Medical Care for Civilian Casualties DEAN A CLARK, M D, Washington

The Establishment of Emergency Base Hospitals HENRY N HOOPER, Washington

Round Table Discussion Conducted by ROBIN C BUECKI, M D, Philadelphia

Motion Pictures Emergency Medical Service and Medical Aspects of Chemical Warfare

*Thursday, 7 45 a m —Staller Hotel*

Breakfast Conference on Public Relations in Wartime MALCOLM T MACEachern, M D, Chicago, presiding  
Hospitals in the News DAVID DIETZ, Cleveland, JOSEPHINE ROBERTSON, Cleveland, HOWARD W BLAKESLEE, New York, THADDEUS ALLEN, Chicago

*Thursday, 9 30 a m —Little Theater, Public Auditorium*

Panel Discussions  
What the Hospital Administrator Should Know About the Newer Procedures and Therapies Developing During the War in Order to Provide Adequate Services for War and Civilian Injuries Conducted by EVERETT I EVANS, M D, Richmond, Va



Head Injuries. MAX M. PIETZ, M.D., Ann Arbor, Mich.

Shock. ALTON W. OCHSNER, M.D., New Orleans.  
Flash Wounds. Captain FREDERICK R. HOOK, M.C., U.S.N., Oakland, Cal.

Burns. VICTOR E. SULLER, M.D., Cincinnati.

Fractures. M. J. R. ARKOLD GINSWOLD, M.C., U.S.A., Atlanta, Ga.

Chest Injuries. CLARENCE HAYFORTH, M.D., Ann Arbor.

Thursday 2:00 p.m. — Little Theater Public Auditorium  
Panel Discussions

Maintaining Standards of Service in Hospitals During the Present War. Conducted by EDGAR BLANCH, Chicago.

Importance of Maintaining Peacetime Standards of Hospital Services Not Directly Related to the War. ROBERT JONES, Houston, Texas.

Maintaining the Quality of Medical Staff Conferences and Pathological Conferences for the Thorough Review and Analysis of the Clinical Work. VICTOR C. HENRY, M.D., Los Angeles.

Maintaining Standards of Pathological Service in Civilian Hospitals in View of the Need of the Armed Forces for Pathologists and Technicians. FRANK W. HARTMAN, M.D., Detroit.

Maintaining Standards of X-ray Services in Civilian Hospitals in View of the Need of Radiologists and Technicians for the Armed Forces. B. R. KRAMER, M.D., Rochester, Minn.

Thursday 7:30 p.m. — Little Theater Public Auditorium  
Motion Pictures—A program of interesting motion pictures for hospital personnel.

Friday 9:30 a.m. — Little Theater Public Auditorium

Panel Round Table Conference

Problems Affecting Hospitals During Wartime and Postwar Adjustments. ROBERT C. BEYER, M.D., Philadelphia; ROBERT JONES, Houston, Texas; M. J. COHEN, T. MAC EACHERN, M.D., Chicago.

The war has brought many new problems to confront our hospitals in rendering service to the patient. These problems are in the main most difficult to solve and some of them appear insurmountable. The only way in which they can be approached, with hope of solution is to regard each one as a challenge to superior effort in the all-out program to win the war. The hospital must support the military services to the fullest extent and at the same time it must not neglect the health defense of the community. If this conference shall consider ways and means of overcoming the difficulties of maintaining adequate service in all departments of the hospital which contribute to the care of the patient.

Friday 1:00 p.m. — Music Hall Public Auditorium

Panel Discussion

Evacuation and Hospitalization of Wounded in Theater of Operation. Leaders: Captain JOHN P. O'NEAL, M.C., U.S.N., Operation, V.; Lieutenant Colonel A. L. GORRY, M.C., U.S.A., Washington.

Friday 7:00 p.m. — Little Theater Public Auditorium  
Conference on Medical Motion Pictures—Making and evaluating medical motion pictures.

Friday 10:00 p.m.

Study tour of local hospitals.

## GENERAL ASSEMBLY—WAR SESSION

*Tuesday, 9 30 a m —Music Hall, Public Auditorium*

- W EDWARD GALLIE, M D , Toronto, President, American College of Surgeons, Presiding  
 Presentation of the Report of Field Activities of the American College of Surgeons for 1942, and Summariza-  
 tion of a Quarter Century of Hospital Standardization IRVIN ABELL, M D , Louisville, Chairman,  
 Board of Regents, American College of Surgeons  
 Medical and Hospital Service in Canada During the War W EDWARD GALLIE, M D , Toronto  
 United States Army Medical Service in the War Major General JAMES C MAGEE, Surgeon General, United  
 States Army, Washington  
 United States Naval Medical Service in the War Rear Admiral ROSS T MCINTIRE, Surgeon General,  
 United States Navy, Washington  
 The Health of the Nation in Wartime, Surgeon General THOMAS PARRAN, M D , United States Public  
 Health Service, Washington  
 Civilian Defense in Its Relation to Medical and Hospital Service GEORGE BAEHR, M D , Medical Direc-  
 tor (R.), U S P H S , Chief Medical Officer, United States Office of Civilian Defense, Washington  
 The Procurement and Assignment Service FRANK H LAHEY, M D , Boston, Chairman, Directing Board,  
 Procurement and Assignment Service

## PRESIDENTIAL MEETING AND CONVOCATION

*Tuesday, 8 15 p m —Music Hall, Public Auditorium*

- W EDWARD GALLIE, M D , Toronto, President, American College of Surgeons, Presiding  
 Processional—Officers, Regents, and Honorary Guests  
 Invocation  
 Address of Welcome THOMAS E JONES, M D , Cleveland, Chairman, Committee on Arrangements  
 Introduction of Foreign Guests ARTHUR W ALLEN, M D , Boston, Vice Chairman, Board of Regents  
 Representing the Medical Department of the United States Army Major General JAMES C MAGEE, Sur-  
 geon General, United States Army, Washington  
 Representing the Medical Department of the United States Navy Rear Admiral ROSS T MCINTIRE,  
 Surgeon General, United States Navy, Washington  
 Representing the United States Public Health Service THOMAS PARRAN, M D , Surgeon General, United  
 States Public Health Service, Washington  
 Representing the Office of Civilian Defense GEORGE BAEHR, M D , Medical Director (R ), U S P H S ,  
 Chief Medical Officer, United States Office of Civilian Defense, Washington  
 Address of the Retiring President W EDWARD GALLIE, M D , Toronto  
 Inauguration of Officers  
 President IRVIN ABELL, M D , Louisville  
 First Vice President LELAND S MCKITTRICK, M D , Boston  
 Second Vice President F PHINIZY CALHOUN, M D , Atlanta  
 Presentation of Initiates for Fellowship ARTHUR W ALLEN, M D , Boston, Vice Chairman, Board of  
 Regents  
 Conferring of Fellowships by the President IRVIN ABELL, M D , Louisville  
 Conferring of Honorary Fellowships The President  
 Medical Records Prize Award FREDERIC A BESLEY, M D , Waukegan, Ill

## FORUM ON FUNDAMENTAL SURGICAL PROBLEMS

*Wednesday, Thursday, Friday, 9 00 a m to 12 30 p m —Music Hall, Public Auditorium*

- Presentation of the results of clinical and experimental research on problems related to general surgery and  
 the surgical specialties being currently conducted in many of the medical schools, clinics, and hospitals  
 (See page 529)

## EVENING SESSION

*Wednesday 8:00 p.m.—Music Hall, Public Auditorium*

IRVIN ABELL, M.D. Louisville. President, American College of Surgeons, Presiding.  
 Annual Oration on Surgery: Wounds in Combat. Captain FREDERICK R. HOOK, M.C., U.S.A. Oakland, Calif.

Symposium—Medical Aspects of the War

Preventive Aspects of Tropical Diseases. Captain CHARLES S. STEPHENSON, M.C., U.S.A. Washington.  
 The Infectious Disease Problem of the Army. Colonel HUGH J. MORGAN, M.C., U.S.A. Washington.  
 The Control of Venereal Disease in the Army. Lieutenant Colonel T. B. TURNER, M.C. U.S.A. Washington.

Gynecology and Obstetrics in Their Relation to the War. JAMES R. MILLER, M.D. Hartford, Conn.

## CANCER SYMPOSIUM

*Thursday 9:00 a.m.—Room C, Public Auditorium*

FRANK E. ADAIR, M.D. New York. Chairman, Cancer Committee. Presiding.  
 Report of an Experiment to Control Cancer of the Uterus by Means of Periodic Pelvic Examination. CATHERINE MACFARLANE, M.D. Philadelphia.  
 Technical Difficulties of Lung Surgery in the Cancer Patient with Consideration of the Anesthesia Problems. EVARTS A. GRAHAM, M.D. St. Louis.  
 Amended Cancer Statistics. THOMAS DUFFIELD, Ph.D. New York.  
 Extending Surgery for Abdominal Carcinoma. ALEXANDER BRUNSWIC, M.D. Chicago.  
 Survey of Problems Connected with Cancer Clinics. Captain CHARLES A. WATMAN, M.C., U.S.A. Atlanta.  
 Five year Cures of Cancer. BOWMAN C. C. OWELL, M.D. Chicago.

## PANEL DISCUSSIONS

*Friday 7:00 p.m.—Music Hall, Public Auditorium*

Treatment of Traumatic Shock. ALFRED BLALOCK, M.D. Baltimore. Presiding.  
 Statement of Problem and Consideration of Early Signs. DALLAN B. PRINGLE, M.D. Chicago.  
 Fluid Administration—Quality and Quantity. HENRY V. HARRIS, M.D. Detroit.  
 Use of Tourniquet, of Heat, and of Cold. ALFRED BLALOCK, M.D. Baltimore.  
 Anesthesia in Shock. HEAVY K. BECKER, M.D. Boston.

Treatment of Burns. ALFRED BLALOCK, M.D. Baltimore. Presiding.  
 General Treatment. JOSEPH E. RHODES, M.D. Philadelphia.

Local Treatment

Tannic Acid. ROY D. McCLELLAN, M.D. Detroit.  
 Triple Dyes. ROBERT H. ALDRICH, M.D. Boston.  
 Sulfonamides. LESTER R. DRAUGHT, M.D. Chicago.  
 Some Physical and Chemical Aspects of the Local Treatment of Burns. FRANK C. SCHWENK, M.D. Belleville, N.J.

Pressure Dressings. SUMNER L. KOCK, M.D. Chicago.  
 Early Skin-Grafting. EARL C. PADGETT, M.D. Kansas City, Mo.

Blood and Blood Substitutes. ALFRED BLALOCK, M.D. Baltimore. Presiding.  
 Whole Blood. MICHAEL E. DEBAKEY, M.D. New Orleans.  
 Plasma and Serum. ROBERT LOEB, M.D. New York.

Albumin CHARLES A JANEWAY, M D , Boston

Army and Navy Packages Lieutenant Commander L R NEWHOUSER, M C , U S N , Bethesda, Md

Other Substitutes ROBERT ELMAN, M D , St Louis

Combating Chemical Warfare ALFRED BLALOCK, M D , Baltimore, Presiding

Burns JOHN S LOCKWOOD, M D , Philadelphia

Gas Poisoning, Decontamination Centers MILTON C WINTERNITZ, M D , New Haven, Conn

The Emergency Treatment of Casualties Captain EDWARD F LEWISON, M C , U S A , Edgewood Arsenal, Md

*Wednesday, 1 00 p m —Music Hall, Public Auditorium*

The Treatment of Wounds ALLEN O WHIPPLE, M D , New York, Presiding

First-Aid Treatment

Definitive Treatment FREDERICK A COLLIER, M D , Ann Arbor, Mich

Hospital Treatment, Early and Final Captain FREDERICK R HOOK, M C , U S N , Oakland, Calif ,  
Colonel NORMAN T KIRK, M C , U S A , Battle Creek, Mich

Infected Wounds FRANK L MELENEY, M D , New York

Clean Wounds MONT R REID, M D , Cincinnati

Urological Injuries CHARLES C HIGGINS, M D , Cleveland

Abdominal Injuries ROSCOE R GRAHAM, M D , Toronto, ARTHUR W ALLEN, M D , Boston

Injuries to Blood Vessels

Injuries to Peripheral Nerves HENRY C MARBLE, M D , Boston

*Thursday, 3 00 p m —Music Hall, Public Auditorium*

Treatment of War Injuries to the Chest EVARTS A GRAHAM, M D , St Louis, Presiding

Sucking Wounds and Open Pneumothorax EVARTS A GRAHAM, M D , St Louis

Wounds of the Heart ISAAC A BIGGER, M D , Richmond, Va

Wounds of the Lungs

Combined Thoracic and Abdominal Wounds CLAUDE S BECK, M D , Cleveland

Pulmonary Tuberculosis in Soldiers

*Thursday, 4.45 p m —Music Hall, Public Auditorium*

Anesthesia for War Surgery RALPH T KNIGHT, M D , Minneapolis, Presiding

Anesthesia Used at Pearl Harbor

The Place of Intravenous Anesthesia in War Surgery JOHN S LUNDY, M D , Rochester, Minn

The Place of Spinal and Regional Anesthesia in War Surgery Major CHARLES F MCCUSKEY, M C ,  
U S A , San Francisco

The Place of Inhalation Anesthesia in War Surgery KENNETH C MCCARTHY, M D , Toledo

Anesthesia for Special Surgery and Special Situations RALPH T KNIGHT, M D , Minneapolis

*Thursday, 8 00 p m —Music Hall, Public Auditorium*

Lieutenant Colonel ROBERT H KENNEDY, M C , U S A , Washington, Presiding

Refrigeration Anesthesia for Surgery of the Extremities, LYMAN W CROSSMAN, M D , New York

Oration on Fractures and Other Traumas Amputations Colonel NORMAN T KIRK, M C , U S A , Battle Creek, Mich

Panel Discussions on Fractures

Fractures and Accompanying Injuries of the Hand Leader HENRY C MARBLE, M D , Boston

Collaborators CONDUCT W CUTLER, M D , New York, J H COUCH, M D , Toronto

Fractures into the Knee Joint

Compound Fractures Leader WALLACE H COLE, M D , St Paul

Collaborators FRASER B GURD, M D , Montreal, GUY A CALDWELL, M D , New Orleans, Major

R ARNOLD GRISWOLD, M C , U S A , Atlanta

*Friday 1:00 p.m.—Music Hall, P. M. Auditorium*

Evacuation and Hospitalization of Wounded in Theaters of Operation. Captain JOHN P. OWEN, M.C., U.S.N. Quantico, Va., and Lieutenant Colonel A. L. GOODY M.C., U.S.A., Washington, Presiding

*Friday 2:00 p.m.—Ballroom Public Auditorium*

Treatment of War I Injuries to the Skull. HOWARD C. NAVTSON, M.D. San Francisco, Presiding

Experimental Study of Penetrating Wounds and Infections of the Brain. CORB PILCHER M.D. Nashville, Tenn.

Experiences of the Canadians and English with Cranio-cerebral Injuries. WILLIAM V. COOK, M.D. Montreal

Compound Depressed Fractures and the Operative Treatment of Penetrating Wounds of the Head. CLAUDE C. COLEMAN M.D. Richmond GILBERT HOWARD, M.D. Boston Commander W. McK. CRAIG, M.C. U.S.N. Bethesda, Md.

*Friday 4:30 p.m.—Ballroom Public Auditorium*

Treatment of War Injuries to the Face. ROBERT H. IVY M.D. Philadelphia, Presiding.

General Outline of Early and Late Treatment. ROBERT H. IVY M.D. Philadelphia.

Fractures of Facial Bones, and Injuries Involving Nasal Accessory Sinuses. WILLIAM MINTON ADAMS, M.D. Memphis, Tenn.

Ocular and Orbital Injuries. EDWARD B. SPARTO, M.D. Philadelphia.

Repair of Soft Tissue Injuries to the Face. FERRIS SMITH, M.D. Grand Rapids, Mich.

## COMMITTEE MEETINGS

IRVY ABELL, M.D. Louisville Chairman Board of Regents, Presiding

### STATE AND PROVINCIAL JUDICIARY COMMITTEES

*Wednesday 9:30 a.m.—Room C Public Auditorium*

Statement by the Chairman of the Board of Regents.

Selection and Appointment of Judiciary Committees

Procedure in Dealing with Judiciary Cases

Types of Cases Referred to the Judiciary Committees

Discussion by Fellows and Regents of the College

### STATE AND PROVINCIAL EXECUTIVE COMMITTEES

*Wednesday 10:00 a.m.—Room C Public Auditorium*

Statement by the Chairman of the Board of Regents.

Work Sessions Held in 1942 and Plans for Meetings in 1943

Discussion by the Fellows and Regents of the College

### CREDENTIALS COMMITTEES AND COMMITTEES ON APPLICANTS

*Wednesday 10:30 a.m.—Room C Public Auditorium*

Statement by the Chairman of the Board of Regents.

Summary of Work of Credentials Committees and Committees on Applicants, 1942

Demonstration—Interviewing Candidate for Fellowship by Committee on Applicants

The Junior Candidate

Discussion by the Fellows and Regents of the College

## OPHTHALMOLOGY AND OTOLARYNGOLOGY

## GROUP CLINICAL CONFERENCES

*Wednesday, 11 00 a m*

- Perforating Wounds of the Eyeball THOMAS D ALLEN, M D , Chicago, Presiding  
 Collaborators DANIEL P HORNBOKEN, M D , Marquette, Mich , BERNARD J LARKIN, M D , Indianapolis,  
 FREDERICK O SCHWARTZ, M D , St Louis, WALTER S ATKINSON, M D , Watertown, N Y
- Prophylaxis and Therapy of the Common Cold ALBERT C FURSTENBERG, M D , Ann Arbor, Mich ,  
 Presiding

*Thursday, 11 00 a m*

- Surgery of Orbital Tumors WILLIAM L BENEDICT, M D , Rochester, Minn , Presiding  
 Collaborators WALTER E DANDY, M D , Baltimore, J GRAFTON LOVE, M D , Rochester, Minn ,  
 DONALD J LYLE, M D , Cincinnati
- Management of Acute Respiratory Obstruction Specifically Related to the Larynx and the Tracheobronchial  
 Tree. CHEVALIER L JACKSON, M D , Philadelphia, Presiding

*Friday, 11 00 a m*

- Chemical Injuries to the Eye, Including War Gases CONRAD BERENS, M D , New York, Presiding  
 Collaborator ELBERT S SHERMAN, M D , Newark
- Otic Complications of Skull Fractures WILLIAM E GROVE, M D , Milwaukee, Wis , Presiding

## PANEL DISCUSSIONS

*Wednesday, 8 30 p m —Rooms A and B, Public Auditorium*

- Traumatic Unilateral Lens Injury DANIEL B KIRBY, M D , New York Presiding
- Treatment of Wounds of the Neck

*Thursday, 8 00 p m —Rooms A and B, Public Auditorium*

- Extra Ocular Injuries WILLIAM L BENEDICT, M D , Rochester, Minn , Presiding  
 Collaborators HARRY S GRADLE, M D , Chicago, ALBERT D RUEDEMANN, M D , Cleveland, BRITAIN  
 F PAYNE, M D , New York
- Treatment of Burns of the Face GORDON B NEW, M D , Rochester, Minn , Presiding  
 Collaborator ALFRED W FARMER, M D , Toronto

*Friday, 8 00 p m —Ballroom, Public Auditorium*

- Treatment of War Injuries to the Skull HOWARD C NAFFZIGER, M D , San Francisco, Presiding (See  
 complete program on page 538 )
- Treatment of War Injuries to the Face ROBERT H IVY, M D , Philadelphia, Presiding (See complete  
 program on page 538 )

## ASSEMBLY OF INITIATES

*Tuesday 1 on p.m.—Ballroom Public Auditorium*

W EDWARD GALLIE, M.D. Toronto President, Presiding.

Processional—Officers, Regents, and Governors.

Opening Remarks. W EDWARD GALLIE, M.D. Toronto President.

The Program of the American College of Surgeons.

The Department of Clinical Research—Cancer Fractures and Other Traumas. Hall of the Art and Science of Surgery. BOWMAN C. CROWELL, M.D. Chicago Associate Director.

Hospital Standardization. War Sessions. Graduate Training in Surgery. Library and Department of Literary Research. MALCOLM T. MACLEACH, M.D. Chicago Associate Director.

The Fellowship Pledge. Recital by Initiates.

Fellowship in the College. IRVING ABELL, M.D. Louisville Chairman, Board of Regents.

Signing of the Fellowship Roll. The Initiates.

Reception by the Officers and Regents for the Initiates and Fellows and members of their families.

## ANNUAL MEETING BOARD OF GOVERNORS

*Wednesday 12:00 M.—Stoker Hotel*

IRVING ABELL, M.D. Louisville President, American College of Surgeons, Presiding.

Statement by the Chairman of the Board of Regents. IRVING ABELL, M.D. Louisville.

Types of Problems Encountered by the Administrative Board and the Central Committee on Credentials and Methods of Dealing with Them. FREDERIC A. BESLEY, M.D. Waukegan Secretary. MALCOLM T. MACLEACH, M.D. Chicago, Chairman, Administrative Board. BOWMAN C. CROWELL, M.D. Chicago Vice Chairman Administrative Board.

Discussion by the Governors and Regents.

## ADJOURNED MEETING BOARD OF GOVERNORS

*Thursday 1:30 p.m.—Music Hall Public Auditorium*

Report of Committee on Nominations to the Board of Governors.

## ANNUAL MEETING FELLOWS OF THE COLLEGE

*Thursday 1:45 p.m.—Music Hall Public Auditorium*

IRVING ABELL, M.D. Louisville President, American College of Surgeons, Presiding.

Report of Committee on Nominations to the Fellows.

Library and Department of Literary Research. MISS L. M. ROBERTS PRINE, Chicago Librarian.

Financial Report. DALLAS B. PRINSTER, M.D. Chicago Treasurer.

Departmental Reports: (a) Hospital Standardization. (b) Work of Credentials Committees, Committee on Applicants, and Committee on History Reviews. (c) War Sessions. (d) Medical Motion Pictures. (e) Public Relations. MALCOLM T. MACLEACH, M.D. Chicago Associate Director.

Graduate Training in Surgery—General Surgery and the Surgical Specialties. DALLAS B. PRINSTER, M.D. Chicago Chairman, Committee on Graduate Training in Surgery.

Hall of the Art and Science of Surgery. GEORGE CRILE, M.D. Cleveland Chairman, Committee on the Hall of the Art and Science of Surgery.

Committee on Cancer. FRANK E. ADAMS, M.D. New York Chairman.

Committee on Fractures and Other Traumas. Lieutenant Colonel ROBERT H. KENNEDY, M.C., U.S.A. Washington Chairman.

Department of Clinical Research. BOWMAN C. CROWELL, M.D. Chicago Associate Director.

College Administration. FREDERIC A. BESLEY, M.D. Waukegan Secretary.

Fellowship Obligations and Opportunities. ARTHUR W. ALLEN, M.D. Boston Vice Chairman, Board of Regents.

The College in Its Relation to the War Program. IRVING ABELL, M.D. Louisville Chairman Board of Regents.

## PRELIMINARY CLINICAL PROGRAM

## LAKESIDE HOSPITAL

*Tuesday*

## GENERAL SURGERY

- Staff—2 Dry clinic Major factors controlling mortality rate in resections of stomach and bowel  
 CARL H. LENHART Introductory remarks  
 HIRAM O. STUDLEY Percentage weight loss as a basic indicator of surgical risk in patients with chronic peptic ulcer  
 EDWARD MUNTWYLER Basic biochemical considerations with respect to dehydration, salt depletion, acid base balance and hypoproteinemia  
 FREDERICK R. MAUTZ Clinical aspects of dehydration  
 WILLIAM E. ABBOTT Correction of hypoproteinemia by parenteral amino acid  
 FRANK M. BARRY Results obtained by Lakeside house-officers in resections of the stomach and colon over the past year

## OPHTHALMOLOGY

- A. B. BRUNER—2 Conference and discussion Malingering and its diseases  
 M. P. MOTTO—3 30 Conference Strabismus, practical surgical points

*Wednesday*

## GENERAL SURGERY

- JOHN W. HOLLOWAY, RUSSELL H. BIRGE, FRANK S. GIBSON, and FRANK M. BARRY—9 Operative clinic  
 CLAUDE S. BECK—9 Heart operation  
 Staff—2 Dry clinic  
 HARRY GOLDBLATT Hypertension Experimental observations on the present status of surgical treatment  
 PAUL J. SCHILDT Unilateral kidney disease, causing hypertension.  
 JOHN E. WILLIAMS Pheochromocytoma of adrenal gland, causing hypertension, undescended testicle, results of operation, exhibit of pyelograms

## GENITOURINARY SURGERY

- JOHN E. WILLIAMS, PAUL J. SCHILDT, and JAMES J. LYNCH—9 Operative clinic

## OPHTHALMOLOGY

- M. P. MOTTO—9 Operative clinic.

*Thursday*

## GENERAL SURGERY

- HARRY G. SLOAN, ERNEST F. BRIGHT, ROBERT M. HOSLER, WILLIAM D. HOLDEN, and EDWARD P. JUDD—9 Operative clinic.  
 CLAUDE S. BECK—2 Dry clinic Surgical lesions of the heart, demonstration of patients, illustrating various surgical topics

## ORTHOPEDIC SURGERY

- MAXWELL HARBIN, CLARENCE H. HEYMAN, and JOHN A. MURPHY—9 Operative clinic.

## THORACIC SURGERY

- S. O. FREEDLANDER—9 Operative clinic

## OPHTHALMOLOGY

- L. V. JOHNSON and MR. LCKER—9 Conference and demonstration Riboflavin and its uses in ophthalmology

*Friday*

## GENERAL SURGERY

- CARL H. LENHART, FREDERICK R. MAUTZ, and FRANK S. GIBSON—9 Operative clinic.  
 CLAUDE S. BECK—9 Heart operation

## GENITOURINARY SURGERY

- THOMAS P. SHUPE—9 Operative clinic

## OPHTHALMOLOGY

- C. I. THOMAS—9 Operative clinic

## MATERNITY HOSPITAL

*Wednesday*

## OBSTETRICS AND GYNECOLOGY

- A. H. BILL, W. H. WEIR, W. R. BARNEY, R. L. FAULKNER, F. S. MOWRY, and J. L. REYCRAFT—9 Operative and dry clinic  
 A. H. BILL, W. H. WEIR, W. R. BARNEY, R. L. FAULKNER, F. S. MOWRY, and J. L. REYCRAFT—2 Dry clinic.

*Thursday*

## OBSTETRICS AND GYNECOLOGY

- A. H. BILL, W. H. WEIR, W. R. BARNEY, R. L. FAULKNER, F. S. MOWRY, and J. L. REYCRAFT—9 Operative and dry clinic  
 A. H. BILL, W. H. WEIR, W. R. BARNEY, R. L. FAULKNER, F. S. MOWRY, and J. L. REYCRAFT—2 Dry clinic

*Friday*

## OBSTETRICS AND GYNECOLOGY

- A. H. BILL, W. H. WEIR, W. R. BARNEY, R. L. FAULKNER, F. S. MOWRY, and J. L. REYCRAFT—9 Operative and dry clinic

## UNITED STATES MARINE HOSPITAL

*Wednesday*

## GENERAL SURGERY

- S. A. DEMARTINI and staff—9 Operations

*Thursday*

## GENERAL SURGERY

- W. S. MOZDEN—1 Dry clinic Varicose veins, ligations and obliterative treatment  
 C. H. DUSTON—1 Dry clinic Spinal anesthesia.  
 CARL ENNA—1 Dry clinic Postoperative pulmonary complications, demonstration of plasma bank operation

## OPHTHALMOLOGY

- M. E. GANS—9 Dry clinic Eyeground demonstrations

*Friday*

## GENERAL SURGERY

- S. A. DEMARTINI and staff—9 Operations



## CLEVELAND CLINIC HOSPITAL

## Tuesday

## GENERAL SURGERY

ROBERT S. DYMOND—2. Operations.

## GASTROENTERIC SURGERY

WILLIAM E. LOWER and CHARLES C. HODGINS— Operative clinic.

## NEUROLOGIST

W. A. NORTON—2. Operations.

## OTO-LARYNGOLOGY

HAROLD E. HARRIS—2. Operations.  
Staff—2. Dry clinic. Nasal plastic.

## Wednesday

## GENERAL SURGERY

THOMAS E. JONES—9. Operative clinic.  
Staff—9. Dry clinic.

W. A. NORTON—9. Abdominal pain of neurological origin.  
CHARLES C. HODGINS—9. 5. Renal calculi management.  
ALLAN GRAMER—9. 30. Prognosis of malignant tumors.

## STAFF—Symposium: Spleen

RENNELL L. HADICK—5. Indications and contra-indications for splenectomy.

ROBERT S. DYMOND—45. Surgical problems in splenectomy.

B. H. VICKERS—Ulcer atypical lesions about the pylorus.

R. J. F. RICE—30. Experiences in gas gastroscopy.

E. W. COLLIER—50. Indications for surgery in gastric and duodenal ulcer.

ROBERT S. DYMOND—Operations.

## GASTROENTERIC SURGERY

WILLIAM E. LOWER and CHARLES C. HODGINS— Operative clinic.

## ORTHOPEDIC SURGERY

J. A. DICKSON and J. L. KENNEDY—9. Operative clinic.

## NEUROLOGIST

A. T. BENTLEY—9. Operative clinic.

W. A. NORTON—Dry clinic.

## OTO-LARYNGOLOGY

A. D. REIDEMAN—9. Operative clinic.

PAUL G. MOORE—30. Dry clinic.

A. D. REIDEMAN—Conference on esophagology.

## OTO-LARYNGOLOGY

Staff—9. Operative clinic.

HAROLD E. HARRIS—Operative clinic.

## Thursday

## GENERAL SURGERY

THOMAS E. JONES—9. Operative clinic.  
ROBERT S. DYMOND and F. L. SATTEL—Operative clinic.

## FRACTURES AND OTHER TRAUMAS

J. A. DICKSON and J. L. KENNEDY—9. Operations.

## GASTROENTERIC SURGERY

WILLIAM E. LOWER and CHARLES C. HODGINS—Dry clinic. Motion pictures.

## NEUROLOGIST

A. T. BENTLEY—9. Operative clinic.

W. A. NORTON—2. Operative clinic.

## OTO-LARYNGOLOGY

A. D. REIDEMAN—9. Operative clinic.

PAUL G. MOORE—9. Operative clinic.

A. D. REIDEMAN—2. Dry clinic. Vertigo in otitis media.

## OTO-LARYNGOLOGY

HAROLD E. HARRIS—Operative clinic.

## Friday

## GENERAL SURGERY

THOMAS E. JONES—9. Operative clinic.

## ORTHOPEDIC SURGERY

J. A. DICKSON and J. L. KENNEDY—9. Operative clinic.

## NEUROLOGIST

A. T. BENTLEY—9. Operative clinic.

## OTO-LARYNGOLOGY

A. D. REIDEMAN—9. Dry clinic: Esophagology.

P. G. MOORE—9. Operative clinic.

## LAKEWOOD HOSPITAL

## Tuesday

## OBSTETRICS AND GYNECOLOGY

R. A. PEARCE—Dry clinic: Problems of the newborn. Lingual and other skin lesions.

## OTO-LARYNGOLOGY

Staff—Dry clinic: Peroral endoscopy, vertigo due to craniopharyngeal tube obstruction and its treatment.

## Wednesday

## GENERAL SURGERY

C. LEE GRANGER and associates—9. Operative clinic.

C. LEE GRANGER—Dry clinic: Improved and simplified technique for intravenous medication.

## ORTHOPEDIC SURGERY

LOUIS M. S. ARON—9. Operative and dry clinic.

## OTO-LARYNGOLOGY

FOREST W. MILLER—Dry clinic: Vertigo due to craniopharyngeal tube obstruction and its treatment.

## Thursday

## GENERAL SURGERY

NORTH W. SWEET—9. Exhibit of interesting test cases, discussion of radiological problems.

S. ARLEY N. P. DEVELLE and G. C. RANNEY—9. Demonstration of technique for spinal anesthesia.

## GASTROENTERIC SURGERY

L. F. HETTINGER—Urological demonstrations.

## OTO-LARYNGOLOGY

RALPH W. F. ACHESON—9. Operations. Nasal plastic.

Staff—Dry clinic: Peroral endoscopy.

## CITY HOSPITAL

*Tuesday*

## GENERAL SURGERY

L A POMEROY, H H HAUSER, S O FREEDLANDER, and associates—2 Tumor clinic  
H T KARSNER, H Z LUND, and associates—2 Clinical pathological conference

*Wednesday*

## GENERAL SURGERY

S O FREEDLANDER, M B TALIAK, R J McNAMEE, M H LAMBRIGHT, and A M LEIGH—9 Operative clinic  
Gastric resection, cholecystectomy, thyroidectomy, radical mastectomy

Staff—2 Medical and surgical clinic with case presentations and discussion

R W SCOTT Thyroid and heart disease

E F BEARD Hyperparathyroidism

M L SIEGEL Jaundice.

H H HAUSER Treatment of tuberculous lymph nodes by irradiation

Z T WIRTSCHEFFER Bleeding peptic ulcer

R C MCKAY Pulmonary sarcoidosis.

## GENITOURINARY SURGERY

H R TRATTNER and associates—9 Operative clinic  
Radical operation for carcinoma of the prostate, perineal prostatectomy, nephrectomy, prostatic injection through partition catheter

## THORACIC SURGERY

Staff—1 30 Chest conference

S O FREEDLANDER, R C MCKAY, H H HAUSER, and associates—1 30 Selection of cases for medical, surgical and radiological treatment

S O FREEDLANDER and associates—3 10 End results of chest surgery

## OPHTHALMOLOGY

PAUL G MOORE—9 Dry clinic Demonstration of cases

*Thursday*

## GENERAL SURGERY

L A ATLAS and associates—9 Operative clinic Leg amputation, thoracic sympathectomy, lumbar sympathectomy, saphenous vein ligation

S O FREEDLANDER, M B TALIAK, R J McNAMEE, and staff—2 Dry clinic Head, neck, chest, abdomen, extremities, burns

L A ATLAS and staff—2 Dry clinic Diagnosis and treatment of peripheral vascular diseases, lantern slides and case demonstrations

## ORTHOPEDIC SURGERY

G I BAUMAN, L M STARIN, R S REICH, and associates—9 Operative clinic Spinal fusion, repair of ruptured meniscus

G I BAUMAN, L M STARIN, R S REICH, and associates—2 Dry clinic

## OTOLARYNGOLOGY

Staff—2 Dry clinic Demonstration of cases of oral and laryngeal malignancies

*Friday*

## OBSTETRICS AND GYNECOLOGY

J I REYCRAFT and associates—9 Operative clinic

Watkins' interposition and perineorrhaphy, vaginal plastic and panhysterectomy, supracervical hysterectomy

## THORACIC SURGERY

S O FREEDLANDER and M H LAMBRIGHT—9 Operative clinic Lobectomy, pneumonectomy, thoracoplasty

## OPHTHALMOLOGY

G LESLIE MILLER—9 Dry clinic Demonstration of cases

## ST VINCENT'S CHARITY HOSPITAL

*Tuesday*

## OPHTHALMOLOGY

HOWARD SHIRAS and associates—2 Demonstration of cases

*Wednesday*

## GENERAL SURGERY

O A WEBER, E P NEARY, and W H ODELL—9 Operations

## ORTHOPEDIC SURGERY

C G BARBER—9 Operative clinic

## OPHTHALMOLOGY

HOWARD SHIRAS and associates—2 Demonstration of cases

## OTOLARYNGOLOGY

Staff—2 Operative clinic

*Thursday*

## GENERAL SURGERY

E P NEARY, J E HALLISY, and J G BRADY—9 Operative clinic

*Friday*

## GENERAL SURGERY

J E HALLISY, H C NASH, and J G BRADY—9 Operative clinic

## GENITOURINARY SURGERY

H R TRATTNER and L F HUFFMAN—9 Operative clinic

## EVANGELICAL DEACONESS HOSPITAL

*Wednesday*

## GENERAL SURGERY

J R JOHNSON, J H BUDD, and M B TALIAK—9 Operative and dry clinic

*Thursday*

## GENERAL SURGERY

O A WEBER and J H BUDD—9 Operative and dry clinic

*Friday*

## GENERAL SURGERY

J R JOHNSON, J H BUDD, and M B TALIAK—9 Operative and dry clinic

## HURON ROAD HOSPITAL

## Tuesday

## GENERAL SURGERY

Rosewell Lowry—2. Lecture and demonstration. Ultra-violet blood irradiation therapy.  
R. J. Whitacre, B. B. Savory, J. K. Potter, and A. J. Fisher—2. Dry clinic. Recent advances in anesthesia.

## OBSTETRICS AND GYNECOLOGY

A. G. Chenevix, G. H. Ivry, J. and staff—Operative Obstetrics.

## Wednesday

## GENERAL SURGERY

T. S. Jackson and G. M. H. K.—9. Operations. Thyroidectomies and mastectomies.  
R. J. Whitacre, B. B. Savory, J. K. Potter, and A. J. Fisher—9. Dry clinic. Methods in anesthesia.  
Edward Goodsett—Operation of blood bank in general hospital.

## OBSTETRICS AND GYNECOLOGY

H. K. Decker—9. Operations. Gynecological proctoscopy.  
A. G. Chenevix, G. H. Ivry, Jr., and staff—2. Operative Obstetrics.

## ORTHOPEDIC SURGERY

A. H. Rice and staff—9. Operative clinic. Orthopedics and fractures.

## DENTOCRANIAL SURGERY

A. C. Lachelyn—Dry clinic. Pyelograms and their interpretation.

## TOLARYNGOLOGY

G. H. Qc—9. Operations. Harelip and tonsils.

## Thursday

## GENERAL SURGERY

R. R. Rickover, D. H. P. Iversen, and C. C. Perry—9. Operative clinic. Rectal, gastrectomies, biliary tract.  
R. J. Whitacre, B. B. Savory, J. K. Potter, and A. J. Fisher—9. Dry clinic. Methods in anesthesia.

## OBSTETRICS AND GYNECOLOGY

G. J. Salinger—9. Operations. Vaginal hysterectomies.  
A. G. Chenevix, G. H. Ivry, J. and staff—Operative Obstetrics.

## ORTHOPEDIC SURGERY

A. H. Rice—Dry clinic.

## DENTOCRANIAL SURGERY

A. C. Lachelyn—9. Operations. Prostate and kidney.

## OTOLARYNGOLOGY

M. F. Mettenbaum—9. Operations. Nasal plastic.

## Friday

## GENERAL SURGERY

T. S. Jackson—9. Operations. Cholecystectomies.  
A. E. Rindorfer, B. B. Rickover, T. L. Lachelyn, J. and L. L. Ch. Adler—9. Operative clinic.  
R. J. Whitacre, B. B. Savory, J. K. Potter, and A. J. Fisher—9. Dry clinic. Methods in anesthesia.

## OPHTHALMOLOGY

William H. Phillips, Josephine Denny Phillips, and C. I. Thomas—9. Operation.

## OTOLOGY

Staff—9. Operative clinic. Selective anastomosis in vocal operations.

## FAIRVIEW PARK HOSPITAL

## Tuesday

## OBSTETRICS AND GYNECOLOGY

E. D. Saunders and T. M. Wells—Operative clinic.

## Wednesday

## GENERAL SURGERY

H. W. Marenheimer and J. R. Keller—9. Operative clinic.

## DENTOCRANIAL SURGERY

L. F. Hertz—Operative clinic.

## Thursday

## GENERAL SURGERY

W. E. Smith and F. H. J. Hertz—9. Operative clinic.

## OBSTETRICS AND GYNECOLOGY

E. D. Saunders and T. M. Wells—Dry clinic.

## ORTHOPEDIC SURGERY

G. L. Bacha—9. Operative clinic.

## Friday

## GENERAL SURGERY

H. W. Marenheimer, F. H. J. Hertz, W. E. Smith, and J. R. Keller—9. Operative clinic.

## LUTHERAN HOSPITAL

## Tuesday

## GENERAL SURGERY

Staff—Surgical conference.

## Wednesday

## GENERAL SURGERY

Harry C. Egan—9. Operative clinic.  
Staff—Surgical conference.

## DENTOCRANIAL SURGERY

Thomas P. Seely—Operative clinic.

## Thursday

## GENERAL SURGERY

Frank B. Gibson and Jerry Borch—9. Operative clinic.  
Staff—Surgical conference.

## Friday

## GENERAL SURGERY

Dwight S. Sprague—9. Operative clinic.

## OPHTHALMOLOGY

James T. Collins—9. Operative clinic.

## OTOLOGY

James T. Collins—9. Operative clinic.

## MOUNT SINAI HOSPITAL

*Wednesday*

## GENERAL SURGERY

ABRAHAM STRAUSS and staff—9 Operative clinic  
B S KLINE and members of the departments of medicine and surgery—10 30 Symposium Allergy and its relation to surgery

## OBSTETRICS AND GYNECOLOGY

J L BUBIS, M E GARBER, and staff—9 Operative clinic  
M E GARBER and ANNA YOUNG—2 Dry clinic Endometriosis, its clinical and pathological aspects  
J L BUBIS—2 Dry clinic Puerperal gynecology, results of 25 years' practice

## ORTHOPEDIC SURGERY

R S REICH—10 30 Dry clinic Treatment of ununited fracture of neck of femur, comminuted fracture of calcaneus, recent and old, treatment of compression fracture of spine, with special emphasis on late reduction

## GENITOURINARY SURGERY

P A JACOBS and staff—9 Dry clinic

## OPHTHALMOLOGY

M E GANS and associates—9 Demonstration of eye cases

*Thursday*

## GENERAL SURGERY

ABRAHAM STRAUSS and staff—9 Operative clinic  
S S QUITNER and S BAUMOL—9 Dry clinic Vertigo  
B S KLINE and members of the departments of medicine and surgery—10 30 Symposium Allergy and its relation to surgery

## OBSTETRICS AND GYNECOLOGY

J L BUBIS, M E GARBER, and staff—9 Operations Gynecological.

## ORTHOPEDIC SURGERY

R. S REICH and staff—9 Operative clinic

## GENITOURINARY SURGERY

P A JACOBS—9 Operative clinic.

## OTOLARYNGOLOGY

Staff—9 Dry clinic.

*Friday*

## GENERAL SURGERY

ABRAHAM STRAUSS and staff—9 Operative clinic  
ABRAHAM STRAUSS—10 30 Dry clinic Undescended testes presentation of cases  
B S KLINE—11 Pathological conference, current surgical case.

## OBSTETRICS AND GYNECOLOGY

M E GARBER and J L BUBIS—9 Operations

## ORTHOPEDIC SURGERY

R S REICH—11 Dry clinic Treatment of ununited fracture of neck of femur, comminuted fracture of calcaneus, recent and old, treatment of compression fracture of spine, with special emphasis on late reduction

## ST LUKE'S HOSPITAL

*Tuesday*

## GENERAL SURGERY

Staff—2 Motion pictures Discussions in general surgery, gynecology, obstetrics, plastic surgery, burns, head surgery, traumatic surgery, orthopedic surgery, genito urinary surgery, and neurosurgery

*Wednesday*

## GENERAL SURGERY

Staff—9 Operations General surgery and surgical specialties  
Staff—2 Motion pictures Discussions in general surgery, gynecology, obstetrics, plastic surgery, burns, head surgery, traumatic surgery, orthopedic surgery, genito urinary surgery, and neurosurgery

## OPHTHALMOLOGY

M W JACOBS and associates—9 Demonstration of cases

## OTOLARYNGOLOGY

Staff—9 Operative and dry clinic Trans antral ethmoid operation, bronchoscopic cases

*Thursday*

## GENERAL SURGERY

Staff—9 Operations General surgery and surgical specialties  
Staff—2 Motion pictures Discussions in general surgery, gynecology, obstetrics, plastic surgery, burns, head surgery, traumatic surgery, orthopedic surgery, genito urinary surgery, and neurosurgery

## OPHTHALMOLOGY

M W JACOBS and associates—9 Demonstration of cases

## OTOLARYNGOLOGY

Staff—9 Operative and dry clinic Laryngectomy, voice production and motion pictures

*Friday*

## GENERAL SURGERY

Staff—9 Operations General surgery and surgical specialties

## OPHTHALMOLOGY

M W JACOBS and associates—9 Demonstration of cases

## OTOLARYNGOLOGY

Staff—9 Hearing tests

WESTERN RESERVE UNIVERSITY  
SCHOOL OF MEDICINE*Wednesday*

## OTOLARYNGOLOGY

Staff—2 Demonstration and scientific exhibit of anatomical specimens, pneumatization of temporal bone

*Thursday*

## OTOLARYNGOLOGY

Staff—2 Demonstration and scientific exhibit of anatomical specimens, pneumatization of temporal bone.

## ST ALEXIS HOSPITAL

## Wednesday

## GENERAL SURGERY

J. F. CORBIN, M. F. KEEGER, E. A. MURPHY, F. A. SMITH,  
FLY, and J. V. WYCKOFF—9 Operative clinic.

## ORTHODONTIC SURGERY

J. A. SOMMER—9 Operative clinic.

## EYE SURGERY

SPENCER BRADY—9 Operative clinic.

## OPHTHALMOLOGY

C. L. McDONALD—9 Operative clinic.

H. V. PRELL—9 Demonstration of cases.

## OTOLOGY

I. W. DELCO and FRED LEBLON—9 Operative clinic.

## Thursday

## GENERAL SURGERY

J. F. CORBIN, L. F. KEEGER, E. A. MURPHY, F. A. SMITH,  
FLY, and J. V. WYCKOFF—9 Operative clinic.

## ORTHODONTIC SURGERY

T. A. WILSON—9 Operative clinic.

## ORTHODONTIC SURGERY

J. A. SOMMER—9 Operative clinic.

## OPHTHALMOLOGY

H. V. PRELL—9 Operative clinic.

## Friday

## GENERAL SURGERY

J. F. CORBIN, M. F. KEEGER, E. A. MURPHY, F. A. SMITH,  
FLY, and J. V. WYCKOFF—9 Operative clinic.

## ORTHODONTIC SURGERY

J. A. SOMMER—9 Operative clinic.

## EYE SURGERY

SPENCER BRADY—9 Operative clinic.

## OPHTHALMOLOGY

C. L. McDONALD—9 Operative clinic.

## OTOLOGY

I. W. DELCO and FRED LEBLON—9 Operative clinic.

## POLYCLINIC HOSPITAL

## Wednesday

## GENERAL SURGERY

P. C. SPILL, H. A. SCHLINK, JOHN T. VITACH, JOHN R. FLETCHER, and HENRY M. SCOTT—9 Operations.

## Thursday

## GENERAL SURGERY

P. C. SPILL, H. A. SCHLINK, JOHN T. VITACH, JOHN R. FLETCHER, and HENRY M. SCOTT—9 Operations.

## ST JOHN'S HOSPITAL

## Tuesday

## GENERAL SURGERY

D. D. STEEL—2 Dry clinic: Tumors of the breast.

## Wednesday

## GENERAL SURGERY

JOHN H. VANDAL, F. T. GALLAGHER, R. THOMAS J. SCHULTZ, and J. R. RUTTON—9 Operations.

## FRACTURES OTHER THAN

R. THOMAS J. SCHULTZ and J. R. RUTTON—9 Dry clinic.

## OTOLOGY

C. L. McDONALD and J. T. COLLIER—9 Operations.

## Thursday

## GENERAL SURGERY

JOHN H. VANDAL, F. T. GALLAGHER, R. THOMAS J. SCHULTZ, and J. R. RUTTON—9 Operations.

## ORTHODONTIC SURGERY

J. R. McDONALD, W. J. MATHIAS, and J. A. SMITH—9 Operations.

## OTOLOGY

JAMES T. COLLIER—2 Dry clinic.

## Friday

## GENERAL SURGERY

JOHN H. VANDAL and F. T. GALLAGHER—9 Operations.

## OBSTETRICS AND GYNECOLOGY

Staff—9 Operations.

## GRACE HOSPITAL

## Tuesday

## OBSTETRICS AND GYNECOLOGY

P. C. F. HARRIS—2 Operative and dry clinic Gynecological.

## OPHTHALMOLOGY

H. W. COOPER—2 Operative and dry clinic.

## OTOLOGY

H. W. COOPER—9 Operative and dry clinic.

## Wednesday

## GENERAL SURGERY

HARRIS C. BARR—9 Operative and dry clinic. Rectal.  
L. J. STRATTON—9 Operative and dry clinic.

## Thursday

## GENERAL SURGERY

F. P. GERACE—9 Operative and dry clinic.  
A. F. HARRIS—9 Operative and dry clinic.  
H. H. MATHIAS—9 Anatomical demonstration.  
W. P. JENNINGS—9 Pathological demonstration.

## Friday

## GENERAL SURGERY

H. M. ADAMS and C. B. MILES—9 Operative and dry clinic.

# SURGERY

## GYNECOLOGY AND OBSTETRICS

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### ANALYSIS OF RELATIONSHIP OF SURGERY AND GASTROSCOPY IN 95 CASES OF GASTRIC TUMOR

RUDOLF SCHINDLER, M D, and PAUL LETENDRE, M D, Chicago, Illinois

PAPERS dealing with the surgical aspects of gastroscopy have been published by Hertel and Kallius, Henning, Korbsch, Carey, Schindler and Giere (12), Barnett, Benedict, and Schindler (11). In this paper an attempt will be made to determine, by an analysis of 95 cases of gastric tumor in all of which a gastroscopy had been performed before operation, the significance of gastroscopy to the surgeon. In 91 of these cases the tumor was a carcinoma in 1 case it was a sarcoma, in 2 cases benign mucosal tumors were present, and in 1 case a benign submucosal tumor. The operations performed in the 91 cases of carcinoma were resection, 64 cases (total gastrectomy in 6 of these), palliative operation of some kind, 7 cases, exploratory laparotomy, 20 cases. In the sarcoma case an exploratory laparotomy was carried out with biopsy, at a second operation resection with extirpation of the spleen and the tail of the pancreas. The benign mucosal tumors, 2 cases, were excised, and a resection was done in the 1 case of benign submucosal tumor.

#### GASTROSCOPIC FAILURES

In 5 of the 91 carcinomas the lesion was not seen gastroscopically (Table VI). In all these

From the Frank Billings Medical Clinic, Department of Medicine, the University of Chicago

5 cases it was known before the gastroscopic examination that a carcinoma was present. Nevertheless, in 3 of these cases the tumor remained hidden from view because of its location in the so called "blind area" of the lesser curvature of the antrum. In fact, there exist gastroscopically three well known "blind areas," areas which because of anatomic reasons cannot be seen at gastroscopic examination, namely (1) the lesser curvature of the antrum, as mentioned before, (2) a small strip of the posterior wall on which the objective of the gastroscope is sliding and from which it can not be abducted sufficiently to get a picture, and (3) the lower pole of the stomach. No tumors of the last two "blind areas" were overlooked. The other 2 carcinomas, not seen, surrounded and infiltrated the pyloric ring. At gastroscopy the antrum was well observed and peristaltic waves were seen migrating toward the pyloric end of the antrum, finally closing its lumen completely, thus giving the impression of a true pylorus formation. However, comparison with the x-ray findings and later with the specimen showed that this closing did not take place at the level of the true pylorus but proximally to it thereby hiding the pyloric tumor. The fact that a pyloric carcinoma may escape view at gastroscopy, although an apparent pylorus is seen, should be borne in mind. Most pyloric

TABLE I.—CORRECT GASTROSCOPIC AND X RAY DIAGNOSIS<sup>1</sup>

Patient Case No.	Gastroscopic impression	X ray impression	Surgical or pathological diagnosis
C. L. 146133	Large carcinoma along lesser curvature Distal antrum to cardia	Cannot rule out possibility of small carcinoma just up on lesser curvature of stomach, so typed examinations	Large carcinoma infiltrating stomach along lesser curvature and antrum
W. C. 137353	Circumscribed carcinoma in antrum and along lesser curvature of stomach	Gastric carcinoma	Gastric carcinoma adherent to pancreas
M. M. 124	Carcinoma of forest	Carcinoma medial portion cardiac end of stomach	Gastric carcinoma, perforating duodenum
M. M. 11437	Circumscribed carcinoma of antrum	Large ulcerating carcinoma of the stomach	Gastric carcinoma, infiltrating liver
J. A. W. 137364	Extensive carcinoma lesser curvature and anterior wall of stomach	Carcinoma of stomach	Extensive gastric carcinoma
A. C. S. 137748	Infiltrating carcinoma of antrum	Gastric carcinoma	Gastric carcinoma
J. E. E. 131176	Stage ulcerated carcinoma of antrum	Large carcinoma of antrum	Carcinoma distal part of stomach
S. L. B. 1334	Carcinoma in lower ring stomach	Polypoid infiltrating type of carcinoma, duodenal portion antrum	Polypoid carcinoma pylorus
S. L. B. 109147	Stage protrusion anterior wall. Pictorial suggestive of gastric carcinoma	Carcinoma protruding gastric ulcer (Malignant? Benign?)	Carcinoma protruding from lesser curve (antrum and posterior wall stomach)
M. C. W. 131736	Inoperable to cutate or it antrum right back (along only seen in cases of further-back stomach (antrum phosia))	Scattered carcinoma of stomach	Gastric carcinoma with metastases to liver
J. M. 1376	Infiltrating carcinoma near antrum	Organic lesion near pylorus, small neoplasm	Small carcinoma, pyloric portion of stomach
G. K. 133008	Curry-wood tumor of pylorus about distal carcinoma of pyloric canal	Large ulceration lesion antrum probably malignant	Carcinoma of carcinoma distal and antrum
H. O. 109147	Mass ulcerated carcinoma extending from anterior wall up to cardia	Polypoid carcinoma involving antrum and body of stomach	Carcinoma involving nearly whole stomach
J. U. 13700	Circumscribed carcinoma antrum	Large infiltrating carcinoma of lower half of stomach	Carcinoma along lesser curvature of stomach
E. B. 131417	Carcinoma lower curvature stomach immediately below cardia	Carcinoma cardiac end of stomach	Large carcinoma of lesser curvature of stomach
L. 10779	Large infiltrating carcinoma involving entire stomach	Large carcinoma body of stomach	Large gastric carcinoma
J. J. 141180	Stage mucous carcinoma along gastric curvature stomach	Defect along greater curvature stomach (Lymphoma?)	Gastric carcinoma adherent to pancreas
O. T. 139416	Gastric carcinoma protruding from lesser curvature (ulcerated depths)	Carcinoma of antrum	Carcinoma lesser curvature of stomach (subperitoneal carcinoma)
L. D. 137054	Stage carcinoma posterior wall stomach	Ulcerating carcinoma of stomach with complete obstruction	Gastric carcinoma, metastases to liver
D. E. 1361	Carcinoma lesser curvature and posterior wall stomach	Large polypoid carcinoma body of stomach	Stage gastric carcinoma
C. B. 137046	Carcinoma infiltrating hole stomach	Carcinoma impeding stomach	Gastric carcinoma, perforating peritoneum
J. E. 10137	Circumscribed polypoid carcinoma posterior wall and greater curvature of stomach	Carcinoma posterior wall and greater curvature stomach	Gastric carcinoma, metastases to liver
A. E. 137046	Carcinoma antrum of stomach	Carcinoma involving whole stomach*	Carcinoma involving great part stomach
J. L. 1307	Infiltrating carcinoma greater curvature stomach	Scattered carcinoma greater curvature stomach	Gastric carcinoma with lymph node metastases
D. E. 136130	Carcinoma antrum stomach	Obstructing carcinoma of antrum	Carcinoma distal part stomach
J. W. 147705	Carcinoma greater curvature stomach	Large ulcerating carcinoma of antrum	Carcinoma involving antrum stomach
E. Y. 109043	Large ulcerated carcinoma	Carcinoma at the angle of stomach	Carcinoma lesser curvature stomach
A. B. 131775	Stage ulcerated carcinoma	Gastric carcinoma	High malignant like papillomatous carcinoma stomach
A. M. 107473	Extensive infiltrating ulcerated carcinoma anterior wall stomach	Carcinoma lesser curvature stomach	Carcinoma of stomach, metastases to liver

# SCHINDLER, LETENDRE SURGERY AND GASTROSCOPY IN GASTRIC TUMOR 549

TABLE I—CORRECT GASTROSCOPIC AND X RAY DIAGNOSIS—Continued

Patient Unit No.	Gastroscopic impression	X ray impression	Surgical or pathological diagnosis
30 A C 264626	Huge carcinoma involving antrum and lower half lesser curvature stomach	Large soft carcinoma pyloric half of stomach	Carcinoma involving entire lesser curvature of stomach
31 J D 264993	Carcinoma of the antrum	Large carcinoma involving antrum and pyloric end of stomach	Large carcinoma distal end of stomach
31 R H 7632	Huge ulcerated carcinoma anterior wall of stomach	Carcinoma of the body of stomach	Large carcinoma upper anterior wall stomach
33 J G 133606	Well limited carcinoma of the pylorus	Neoplastic involvement of the pylorus	Carcinoma involving the pylorus
34 C B 123371	Carcinoma infiltrating antrum angulus lesser curvature and posterior wall of stomach	Large carcinoma posterior wall of stomach	Large gastric carcinoma invasion of gastrohepatic omentum
35 T Y 251546	Ulcerating carcinoma of lesser and great curvature of antrum	Infiltrating ulcerating carcinoma antrum and half lesser curvature of stomach	Carcinoma lesser curvature of stomach
36 A B 201562	Carcinoma upper portion stomach in involving the cardia	Diffuse infiltrating carcinoma upper two-thirds of stomach	Carcinoma proximal part of stomach
37 S C 152133	Diffusely infiltrating carcinoma of almost entire stomach	Carcinoma involving middle half of stomach	Extensive infiltrating carcinoma of the stomach
38 B F 163834	Ulcerated carcinoma antrum and lesser curvature stomach	Ulcerating carcinoma antrum and lesser curvature stomach	Carcinoma distal part of stomach
39 S S 182086	Large ulcerated carcinoma	Ulcerating carcinoma angulus and antrum of stomach	Large ulcerated carcinoma
40 J K 182968	Infiltrating ulcerated carcinoma greater curvature and posterior wall stomach	Ulcerating carcinoma central portion of stomach	Large carcinoma of stomach
41 E J 188610	Carcinoma greater curvature antrum	Large ulcerating carcinoma central portion of stomach	Gastric carcinoma
42 N K 192348	Carcinoma lesser curvature of antrum	Filling defect greater curvature stomach*	Carcinoma distal part of stomach
43 L B 198468	Large carcinoma pyloric canal	Carcinoma antrum stomach	Gastric carcinoma adherent to liver
44 J L 271722	Carcinoma of pylorus	Carcinoma pyloric end of stomach	Gastric carcinoma
45 J N 266300	Infiltrating carcinoma of upper half of stomach	Diffuse infiltrating carcinoma of gastric antrum	Gastric carcinoma hepatic metastases
46 H R 137178	Extensive carcinoma infiltrating lesser curvature stomach	Medullary carcinoma of stomach	Gastric carcinoma lesser curvature
47 M F 157274	Annular infiltrating carcinoma of antrum	Obstruction of pylorus presumably a carcinoma	Carcinoma of antrum
48 J P 116473	Ulcerated carcinoma greater curvature of antrum	Carcinoma pyloric end of stomach	Carcinoma distal end stomach
49 J H 188637	Large carcinoma lesser curvature extending anterior wall and posterior wall of stomach	Annular carcinoma of antrum	Large carcinoma lesser curvature of stomach
50 S H 241004	Large infiltrating carcinoma of stomach	Large ulcerated carcinoma lesser curvature stomach	Carcinoma posterior wall stomach
51 E F 243384	Distention of stomach by air impossible Typical of leather bottle stomach linitis plastica	Ulcerating carcinoma of body of stomach	Large carcinoma involving whole stomach
51 H Z 140390	Large carcinoma involving distal part of stomach	Large scirrhus carcinoma of stomach	Carcinoma distal end of stomach
51 J U 271458	Gastric carcinoma near cardia. Extensive polyposis of stomach	Annular carcinoma of antrum	Local resection of a carcinoma near the cardia Polyps not found by surgeon
52 A S 203367	Huge ulcerated carcinoma posterior wall and lesser curvature of stomach	Carcinoma near cardia with multiple polyps in stomach	Biopsy of gastric wall taken thought to be a hypertrophic gastritis Microscopic diagnosis of biopsy benign adenomas
53 E F 17335	Carcinoma involving almost entire stomach	Large gastric carcinoma Meniscus sign	Gastric carcinoma posterior wall near lesser curvature
54 E C 179783	Organic resistance in upper part of stomach Examination impossible probably a carcinomatous infiltration	Large gastric carcinoma*	Large carcinoma infiltrating nearly entire stomach
		Scirrhus carcinoma of stomach	Carcinoma infiltrating entire stomach

\*Only the first gastroscopic and x ray examination are considered in every case  
\*Indicates an outside case or outside examination



TABLE II.—TUMORS OTHER THAN CARCINOMA

Patient Last No.	Gastroscopic impression	X ray impression	Surgical or pathological diagnosis
M. D. 51154	Well demarcated polypoid carcinoma, posterior wall	Tumor along lesser curvature stomach, probably carcinoma	Benign adenoma
H. B. stopped	Tumor forming part of posterior wall of stomach. Or an ulcerating carcinoma	Indistinct ulcer defect upper lesser curvature stomach?	Hypertrophic polypoid and lenticular masses at posterior of stomach. Erosion of polypoid ulcer opening of stomach
J. L. Q. 11139	Polypus of stomach	Large submucosal masses in stomach	Lymphosarcoma of stomach
A. M. E.	Submucosal mass, probably pyroplasm of stomach wall	Gastric antrum*	Myxosarcoma of stomach

\*Only the first gastroscopic and x-ray examination are considered in every case.

\*Indicates an outside case or outside examination.

carcinomas are so easily and beautifully visualized that the gastroscopist is tempted to exclude the possibility of a pyloric carcinoma as soon as he has seen the contracting pylorus. This obviously is not permissible.

In 5 cases of carcinoma a wrong diagnosis was made (Tables III and V). Retrospectively it may be said that in at least 2 of them the correct diagnosis would have been possible under consideration of all findings. In 2 cases a benign ulcer was diagnosed, and it seems to us remarkable that this number is so small. An extensive discussion of these cases will be found elsewhere (11). In 1 of these cases 3 ulcers were present and only the upper larger one was seen at gastroscopy; the lower one remained hidden behind a callous wall. This lower one however proved to be microscopically a carcinoma; the upper one looked in many sections like a benign ulcer although in some of them strands of carcinomatous tissue were found. In the second case location of the ulcer in the antrum close to the greater curvature bleeding of its edge during the examination and the finding of a second small ulceration should have been interpreted in favor of a malignant growth.

In 2 cases gastritis was wrongly diagnosed. In the paper in which the cases of tumor form-

ing gastritis have been described these cases have not been mentioned but it should be realized that not only a gastritis can be mistaken for a carcinoma, but that a carcinoma can be mistaken for a gastritis. This mistake seems to occur infrequently. In the first of these cases the gastroscopic protocol read:

Half of the pylorus was observed, but no ulcer was seen. There was whitish adherent masses on the greater curvature of the antrum. The greater curvature of the body showed no marked changes. In the lower portions there were some grayish white depressed spots surrounded by red halos. In the upper portions adherent masses and large dark red spots were observed.

Accordingly a severe superficial gastritis of the greater curvature was diagnosed but 6 months later an inoperable carcinoma was found at laparotomy. In the second case the gastroscopic observation should have led to the correct diagnosis.

At x-ray examination a crater of the lesser curvature had been suspected, but no ulcer was found at gastroscopy. However protrusion of the posterior wall was seen, described, and pictured which looked soft and velvety and bled during the examination. The diagnosis of localized hypertrophic gastritis of the posterior wall was made because of the soft appearance, but the bleeding which occurred during the examination should have cautioned us. At laparotomy carcinoma was found and removed.

TABLE III.—INDEFINITE OR INCORRECT GASTROSCOPIC DIAGNOSIS  
CORRECT X RAY DIAGNOSIS<sup>1</sup>

Patient Last No.	Gastroscopic impression	X ray impression	Surgical or pathological diagnosis
C. P. 116151	Gastric ulcer benign? Malpighian pits?	Elevating carcinoma lower posterior stomach	Carcinoma stomach, carcinoma spleen
F. P. 111730	Mass above lesser high lesser curvature ulcer to be benign	Large crater on lesser curvature probably carcinoma	Carcinoma upper lesser curvature of stomach

<sup>1</sup>Only the first gastroscopic and x-ray examination are considered in every case.

Finally a case was observed in which a year ago a carcinoma had been removed by resection. Invagination of intestinal mucosa into the stomach hid the recurrent tumor.

Thus, in 5 of 91 cases of gastric carcinoma the lesion was not seen and in 5 a lesion was seen but a wrong diagnosis was made.

The 1 case of sarcoma of the stomach (Table II, Case 3) was wrongly diagnosed as polyposis but retrospective analysis of the gastroscopic protocol suggests that this mistake might have been avoided. Because of the rarity of the case and its practical significance the protocol is given in full here.

"The whole stomach was seen and the picture was one which I have never seen before. The angulus was seen and below it there was a soft protruding mass which filled almost the entire antrum. The mucosa covering it showed many dark creases and folds. A dark hole in its upper portion seemed to be the way to the pylorus. Although this mass was unusually soft I would not be able to exclude a malignant tumor from this picture alone. But then other protrusions were seen—5 along the posterior wall and 3 along the lesser curvature. Those of the posterior wall were large hemispherical protrusions, which, however, sloped gently toward the gastric wall. They all were covered by a smooth and soft mucosa and no stiffness was observed. However, the highest of them, lying in the fornix, had a somewhat different aspect. Its surface was nodular and had a definitely polypoid character. The 3 protrusions of the lesser curvature were smaller, the two lower ones having about the size of a cherry and the highest one having the size of a plum. They were covered by smooth mucosa. Their elevation was partly so that a shadow was cast on the surrounding mucosa but in other portions of the circumference there was a gradual sloping. The uppermost of these 3 formations contained many nodes of different size and if we would have seen this one alone, we would not be able to differentiate between a benign and a malignant adenoma. Its combination with many other tumors speaks for a benign polyposis. The mucosa surrounding the highest of these tumors and of the whole upper third of the stomach was grayish in color with branching blood vessels. It still should be mentioned that in the groove between the highest and the next highest excrescence of the posterior wall there was a dark red small depression which might or might not be a small ulceration."

It is obvious from this description that no simple polyposis should have been diagnosed. The aspect was not that of a carcinoma, however, and the gastroscopist probably did not think of the possibility of a sarcoma. The

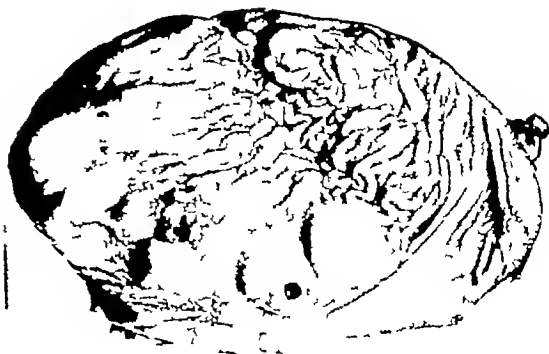


Fig. 1 Gross specimen of a leiomyosarcoma of the stomach. The gastroscopic description, as given in text, corresponds exactly with this picture, but at gastroscopy the wrong diagnosis of a polyposis was made.

gross specimen (Fig. 1) shows that every detail of the gastroscopic examination including the ulceration had been reported clearly.<sup>1</sup>

In one of the benign mucosal tumors (Table II, Case 1), a sharply circumscribed (type I) carcinoma was suspected but the microscopic sections showed rather regular adenomatous tissue. Obviously the differential diagnosis between a large benign adenoma and a just beginning adenocarcinoma always will be difficult gastroscopically as well as microscopically. The second case will be described under the next heading. The one submucosal tumor seen was correctly diagnosed as such at gastroscopy because of the characteristic symptom of "bridging folds" which were crossing the recess between the tumor and the adjacent mucosa. This symptom has been described elsewhere. The tumor proved microscopically to be a submucosal myxoma.

In 4 cases an *indefinite diagnosis* was made (Tables III and V).

We shall call a diagnosis an indefinite one in which the gastroscopist refused to commit himself definitely but admitted that he was unable to make a differential diagnosis, when to a definite diagnosis merely a qualifying

<sup>1</sup>The surgeon not experienced in gastroscopy will be surprised about the detail in relief and colors reported in the gastroscopic protocols. It should be re-emphasized that the gastroscopist sees living tissue and that he is able to make out much more detail (for instance at the edge of an ulcerative lesion) than the surgeon or the pathologist can find at the inspection of the excised bloodless specimen. This fact accounts for the relative ease with which the gastroscopist often correctly differentiates benign and malignant ulcers in cases in which the pathologist is unable to make the differential diagnosis without microscopic examination (9).

TABLE IV—CORRECT GASTROSCOPIC DIAGNOSIS  
INDEFINITE OR INCORRECT X-RAY DIAGNOSIS

Patient Case No.	Gastroscopic impression	X-ray impression	Surgical or pathological diagnosis
T. S. 51	Small infiltrating ulcerated carcinoma of the pylorus	Fract. lesion of the pylorus less an ulcer? Carcinoma	As operation very small pyloric ulcer believed to be benign. Macroscopic diagnosis as by gross carcinoma
O. A. 30955	Ulcerated carcinoma lower curvature stomach	Benign gastric ulcer	Ulcerated gastric carcinoma along lesser curvature
O. B. 33466	Extensive carcinoma involving almost entire stomach	Pyloric obstruction most likely peptic ulcer	Carcinoma involving whole stomach
W. P. 33039	Diffuse infiltrating, ulcerated carcinoma posterior wall stomach	Gastric ulcer	Carcinoma involving lower part stomach
L. W. 337953	Carcinoma surrounding distal end of stomach	Marked pyloric obstruction with deformity of duodenum but with cancer	Carcinoma surrounding distal end stomach
J. B. 33365	Carcinoma of stomach almost completely ulcerated	Obstruction of pylorus large. Malignant?	Carcinoma lower part of stomach
M. L. 33047	Shallow ulcerated carcinoma with bleeding edge toward cardia also. Carcinoma along lesser curvature stomach	Increasing lesion of the pylorus and of stomach and of duodenum both probably peptic ulcer—cannot rule out carcinoma	Carcinoma lower curvature of stomach
L. E. 334	Diffuse ulcerated carcinoma at cardia infiltrated to cardia	Defect in cardia and of stomach—may be carcinoma	Carcinoma involving both stomach and lower part of duodenum
S.	Localized carcinoma of distal portion of the posterior wall close to lesser curvature stomach	Excrescent filling defect along lesser curvature?	Gastric carcinoma, benign carcinoma
B. C. 33333	Large ulcerated carcinoma at cardia	Open or possibly indolent carcinoma lower curvature stomach	Carcinoma involving distal end of stomach
J. C. 33377	Carcinoma in pyloric ring	Increasing lesion in pyloric end of stomach. Carcinoma on surface of lesion being defined	Irregular ulcerated carcinoma pylorus
S. B. 333396	High carcinoma lower curvature stomach and body of stomach	Obstructive lesion at pylorus, antraltrum. Ulcer	Carcinoma lower half of stomach
A. L. 333906	Diffusely infiltrative carcinoma posterior wall of stomach	Organic lesion of lower part greater curvature pylorus, antrum, body and 1 time negative	Carcinoma of stomach posterior wall near lesser curvature
L. L. 3339	Large carcinoma along lesser curvature stomach	Penetrating gastric ulcer cannot absolutely rule out carcinomatous infiltration	Ulcerated carcinoma lower curvature stomach
J. J. 33313	High carcinoma of gastric antrum	Contracting lesion of stomach with possible ulceration. Malignant. Benign?	Carcinoma pyloric end of stomach
M. N. 33363	Ulcerated carcinoma lower curvature of stomach and lower third of lesser curvature stomach	Contracting lesion of gastric angle. Benign? Malignant?	Ulcerated carcinoma lower curvature stomach

Only the first gastroscopic and x-ray examinations are recorded in every case.

\*Indicates an outside case or outside examination.

sentence was added the diagnoses were not considered to be indefinite. The gastroscopist naturally knows that his method is not fool proof and he can not be blamed therefore if he adds the word "probably" to a definite diagnosis. This however occurred very rarely in our material. The gastroscopists tried to be as definite as possible in order to find out the limitations of the method.

The first of the 4 cases with indefinite diagnosis has been reported elsewhere (Table V Case 4). At x-ray examination an ulcer of the posterior wall had been seen and had been interpreted as a benign ulcer. The gastroscopic protocol read:

All parts of the mucosa are swollen and stiff. The folds looked caterpillar like. One fold of the posterior wall as so prominent and thickened that it might have been malignantly infiltrated.

This could not be determined with certainty, however, a short time later the diagnosis of carcinomatous infiltration was made at autopsy. The autopsy performed years later revealed carcinomatous infiltration of the entire stomach. In the second of the cases with indefinite diagnosis (Table V Case 2) an area of infiltration at the midportion of the posterior wall was seen the nature of which the gastroscopist was unable to determine. In the third of these cases (Table III Case 1) the

TABLE V—INDEFINITE OR INCORRECT GASTROSCOPIC AND X-RAY DIAGNOSIS<sup>1</sup>

Patient Unit No	Gastroscopic impression	X ray impression	Surgical or pathological diagnosis
1 C W 257337	Stiff wall like fold along lesser curvature might be malignant	Normal stomach peculiar deformity of antrum	Carcinoma of stomach adherent to pancreas
2 R H 64987	Area of infiltration midportion of posterior wall nature?	Normal stomach	Gastric carcinoma metastases to liver
3 M M 233159	Area of mild hypertrophic gastritis of lower posterior wall	No definite pathology	Small carcinoma on posterior wall
4 G L 162012	Thickening of infiltrated folds unusual inflammatory? Malignant?	Gastric ulcer upper lesser curvature	Gastric carcinoma peritoneal metastases
5 E C 184065	Severe superficial gastritis of greater curvature	Prepyloric ulcer lesser curvature	Carcinoma stomach adherent to pancreas
6 E B 249753	Benign ulcer anterior wall of antrum	Hourglass constriction of antrum due to ulcer probably not gastric carcinoma	Carcinoma pyloric end of stomach
7 M F 184065	Gastric ulcer—slight hypertrophic gastritis Probably invagination of intestinal mucosa rather than tumor	Polypoid mass lesion or redundant mucosa in region of gastroenterostomy	Recurrent carcinoma at the gastroenterostomy

<sup>1</sup>Only the first gastroscopic and x ray examination are considered in every case

gastroscopist saw an ulcer with a wall and stated

"I have never seen so strikingly prominent a delimiting wall in a benign ulcer. If this wall is due to edema in the edge of the ulcer there is at least a 50 per cent chance of its being benign. A very sharply defined, localized large carcinomatous ulcer might give such an appearance."

Operation revealed just such a sharply limited carcinoma.

The last of these indefinite diagnoses (Table V, Case 1) seems to be especially important. The first gastroscopic protocol read

"There was a resistance 3 cm below the cardia and in spite of protracted attempts and two introductions it never became possible to introduce the instrument into the lowest depth of the stomach. The mucosa looked definitely pathological. There was a wall like fold of the lesser curvature and posterior wall which contained hemorrhages but which did not look quite so stiff and infiltrated as we are accustomed to seeing in malignant neoplasms. The mucosa of the fornix and posterior wall were swollen and the greater curvature was slightly protruded. Impression: Unsatisfactory examination. Obstacle 3 cm below the cardia, stiff wall like fold along the lesser curvature which might be the uppermost end of a malignant infiltration, however, I can not commit myself definitely."

The patient was treated medically for 7 months. The operation revealed a carcinoma of the upper portion of the stomach.

Finally a case must be added which cannot be considered as a gastroscopic failure, but rather as an unsatisfactory examination. It was impossible to introduce the gastroscope into the stomach because of a stiff resistance

at the cardia, which later proved to be due to a carcinoma. It should be mentioned that the sensation of the experienced gastroscopist when he tries to overcome an organic resistance is quite characteristic. The introducing fingers feel a stiff board-like resistance which is definitely different from the resilient resistance felt sometimes in spasms. However, some experience is needed for the evaluation of this sensation, but after all extensive experience is required for the interpretation of the gastroscopic pictures also.

#### SUPERIORITY OF GASTROSCOPY TO PALPATION OR INSPECTION

It should not be expected that tumors can be seen at gastroscopy which the surgeon is unable to palpate, nevertheless it does occur. This unexpected superiority of gastroscopy has become apparent in some cases of tumor forming gastritis (8, 10).

Three cases of our series should be quoted in this connection.

In the first instance localized tumor formation was seen in the posterior wall immediately below the cardia (Table II, Case 2). On palpation the surgeon was unable to feel anything. Because of the gastroscopic picture the anterior wall of the stomach was incised. The surgeon introduced his finger into the stomach and then he was able to palpate a number of hard papillomas in exactly the location indicated by the gastroscopist. They were removed bluntly and the mucosa was sutured

TABLE VI.—LESIONS NOT SEEN BY GASTROSCOPY SEEN BY X-RAY

Patient Case No.	Gastroscopic impression	X ray impression	Surgical or pathological diagnosis
A. B. 1935	No tumor seen	Small carcinoma lower curvature pyloric end stomach	Carcinoma antrum of stomach
W. M. 1935	No tumor of pylorus ulcer stability	Constant perpyloric defect, probable carcinoma*	Carcinoma stomach
B. L. 1939	No indication of tumor of the pylorus	Obstruction carcinoma at the neck of the stomach	Carcinoma pyloric end of stomach
B. M. 1939	Normal stomach	Chlorotic hemipnea length of the antrum	Carcinoma involving gastric antrum
C. L. 1940	Tumor not seen lying on blind area of antrum	Ulcer of antrum below pylorus. Or make small tumor possibly of anastomosis	Carcinoma lower cut. end of antrum

\*Only the first gastroscopic and x-ray examinations are considered in every case

\*Indicates an outside view or outside examination

from the inside of the stomach. The growths proved microscopically to be benign hyperplastic polyps.

In the second case—a patient with minor epigastric distress—an ulcer had been seen at x ray within the pyloric canal (Table I, Case 1). At gastroscopy an unusually small cancer of the pylorus with concomitant atrophic gastritis was definitely diagnosed. The surgeon was not able to feel much during the operation and for this reason performed a rather limited resection. The microscopic examination revealed an exceedingly small cancer (8 by 8 millimeters with a depth of  $\frac{1}{2}$  to 2 millimeters). The patient died later from metastases.

In the third case the discrepancy between palpation and inspection at surgical interference and the gastroscopic findings was especially interesting (Table I Case 53). At 2 gastroscopies the following was observed:

The picture seen was unique. I never have seen even approximately similar picture before.

Antrum, angulus, and pylorus are normal, but the entire body presented extensive spectacular changes. Its hole all was somewhat infiltrated and at this infiltration many polypoid rounded hemispherical pea like elevations are seen, partly single partly in groups like flower beds. (At gastroscopy carried out after the operation 26 separate adenomas are counted.) Each single node had normal mucosa and there was no ulceration but the top of each node looked almost flat and thus flat reddish blebbed with the surrounding mucosa. In the lower body a tumor came into view. Toward the anterior wall its surface looked flat and necrotic, toward the posterior all there deep red blebbed (i.e., ulceration). This tumor looked pretty sharply circumscribed. The gastroscopic impression there I regarded as carcinoma of the cardia, extremely polymorphous of the body of the stomach.

However at the operation the surgeon was well able to palpate the circumscribed cancer but he was not able to palpate anything pathological in the body of the stomach beneath this growth. As the neoplasm was sharply defined he decided to make a local excision of the tumor because the general condition of the patient made total gas-

TABLE VII.—LESIONS NOT SEEN BY X-RAY SEEN BY GASTROSCOPY

Patient Case No.	Gastroscopic impression	X ray impression	Surgical or pathological diagnosis
D. L. 1937	Gastric carcinoma consisting of ulcer mixed with wall toward greater curvature	Normal stomach	Ulcer of carcinoma neoplasm of the stomach
J. M. 1938	Large ulcerated carcinoma of antrum no sharp edges	No definite diagnosis made*	Large carcinoma lower part of stomach
W. O. 1938	Polypoid ulcerative carcinoma of antrum	No definite pathological findings*	Large carcinoma lower part of stomach
E. O. 1938	Carcinoma involving curvature of gastric antrum	Normal stomach	carcinoma lower part of stomach
J. R. 1938	Large deep ulcer upper posterior all more likely metastatic	Probably normal stomach	ulcer carcinoma both at posterior wall

\*Only the first gastroscopic and x-ray examinations are considered in every case

\*Indicates an outside view or outside examination



Fig 2 Benign gastric adenoma in a case of multiple adenomas found together with a gastric carcinoma. In spite of the correct gastroscopic diagnosis the surgeon was not able either to palpate the multiple benign tumors or to see them after the opening of the stomach. The biopsy specimen taken was believed to be a part of a hypertrophied gastric fold. The microscopic picture is that of a typical adenoma. At subsequent gastroscopies 26 such tumors were counted.

trectomy too hazardous. After the stomach had been opened the inside of the body was inspected and only hypertrophied mucosa was seen. A biopsy was taken and this proved microscopically to be a typical adenoma (Fig 2). How is it possible to explain the discrepancy between the gastroscopic and the surgical inspection? At the surgical interference the stomach was collapsed, at the gastroscopic examination the stomach was distended with air and by this procedure the relief was unfolded, the many polyps becoming easily distinguishable.

#### COMPARISON OF X-RAY AND GASTROSCOPIC FINDINGS

This paper does not intend to discuss the x-ray aspects of this series. However, the surgeon would like to know whether or not gastroscopy can give him additional information in gastric carcinoma cases not obtained by x-ray. X-ray examination is, and will remain, the standard method for the diagnosis of gastric carcinoma. It has been stated frequently (15) that the close co-operation of

x-ray and gastroscopy will give the most ideal results and the series reported will bear out this fact again. Exactly as in the description of gastroscopic failures only the first x-ray examination will be considered. Its result often was altered by repeat examination, frequently undertaken after the first gastroscopic examination. The diagnosis made by the roentgenologist will not be considered as having been indefinite if there was only a minor qualification such as "probably malignant ulceration" or "benign ulcer but malignant tumor cannot be excluded with the last certainty." Both the gastroscopist and the roentgenologist should make such type of qualification in practically every case since neither method is foolproof. An indefinite diagnosis, however, was assumed if the examiner stated that he was unable to commit himself concerning the differential diagnosis.

Of the 91 gastric carcinomas 8 were not seen at the first x-ray examination (Tables IV, V and VII). In 7 cases a wrong diagnosis was made at the first x-ray examination (benign ulcer), thus, there were 15 failures

If the diagnoses of both methods are put together then the total result becomes rather favorable. In 3 cases the diagnosis was not made with either method. These cases require special discussion. In one of them at x ray some lesion of the lesser curvature was suspected—probably a benign ulcer. At the subsequent gastroscopy this ulcer was not found but a definite bleeding protrusion of the posterior wall was noted but misinterpreted as localized hypertrophic gastritis. Upon re-examining the x ray films it becomes obvious that under consideration of the gastroscopic findings the diagnosis would have been made.

In the second case x ray examination revealed an hourglass constriction of the antrum which was due to an ulcer and probably was not cancerous. A benign ulcer located in the antrum close to the greater curvature, was diagnosed at gastroscopy too. Both, roentgenologist and gastroscopist agreed after the third and second examinations respectively that the lesion might be a cancer whereupon, 4 weeks after the admission a resection was carried out. The patient recovered.

In the third case the lesion was not seen by the gastroscopist but on x ray examination was diagnosed as a benign prepyloric ulcer. This is the only case in which both methods even with our present experience would have led to a wrong diagnosis.

In 3 cases in which the x ray diagnosis was wrong the gastroscopic diagnosis was in definite (suggesting further observation) and in 1 case in which the gastroscopic diagnosis was wrong the x ray diagnosis was indefinite (suggesting further observation).

In summarizing we may say that with sufficient experience the close co-operation between roentgenologist and gastroscopist will lead to excellent results in the diagnosis of gastric carcinoma. Neither method is infallible but used together they will result in error in less than 3 per cent and in indefinite diagnoses in only about 4 per cent of cases.

#### SIZE AND SITE OF TUMOR

If gastroscopic orientation which requires thorough study is understood then the location of the tumor thus revealed will not be difficult. In our series the site of the tumor

was determined always with the greatest possible accuracy.

How far away from the cardia the upper limit of the tumor is located is often a question of importance to the surgeon. Obviously the gastroscopist can answer this question only in so far as the invasion of the mucosa is concerned. The mucosa may not contain any tumor but the tumor may invade the subserosa and serosa at the same level. Therefore the gastroscopist usually is careful when he makes the statement that the gastric wall is not invaded between the upper limit of the tumor and the cardia. Often, however the infiltration of the cardia itself can be definitely noted at gastroscopy. The gastroscopist will also be accurate in his examination of cases in which a wall limits a tumor toward the cardia. The procedure by which the distance of this wall from the cardia is determined is as follows. The gastroscopist is withdrawn slowly until the upper limit of the wall crosses exactly the center of the visual field. At this point the distance from the teeth to the rim of the ocular is taken with a tape measure. Then the gastroscopist is withdrawn again until the neck-shaped fold of the cardia crosses the center of the field. The distance, teeth-ocular is taken once more and subtracted from the first figure. The difference indicates the distance of the wall from the cardia.

The determination of the size of the tumor requires more experience but with experience can be determined rather accurately. The size seen at gastroscopy depends upon the distance of the object from the objective. If close to the objective the lesion appears magnified. If it is remote it appears diminished in size. The beginner who often does not realize how far away from the objective the respective lesion is will usually underestimate its size. In our series no important mistakes were made in the estimation of the size of tumor usually the estimation corresponded very closely with the actual size found at operation.

#### GROSS TYPE OF TUMOR

In recent years it has become customary not to consider all gastric carcinomas as an entity but to classify them according to gross types (3). It has been thought that the final

surgical prognosis might depend upon these gross types (14). Gastroscopecally these types can be diagnosed correctly only if the entire circumference of the tumor is seen, or if the diffuse infiltrative nature of the lesion is beyond any doubt. Our experience has taught us to be cautious.

In 17 of 91 cases of gastric carcinoma no gross typing was possible at gastroscopy.

Three cases were believed to belong to Borrmann's type 1. The type 1 carcinoma is the sharply circumscribed polypoid growth. Two of these 3 cases proved to be type 1 carcinomas in the resected specimen, but one of them was a type 2 carcinoma, the wall of which emerging behind the angulus wrongly suggested a polypoid tumor.

Fifteen cases were believed to belong to type 2 at gastroscopy. Borrmann's type 2 is the sharply limited carcinomatous ulcer which often is surrounded by a high wall. This type gives the most colorful gastroscopic pictures and usually can be easily recognized. Fourteen proved to be type 2 carcinomas in the resected specimen and only 1 of them was a diffusely infiltrating type 4 carcinoma.

In 20 cases a type 3 carcinoma was diagnosed. The carcinomatous ulcer of Borrmann's type 3 is rather sharply limited only at one side but it shows diffuse blending and infiltration at the other side. In 19 cases this gastroscopic diagnosis proved to be correct, and in only one case it was wrong. This case, however, seems to us to be important because it later proved to be a type 2 carcinoma.

In 36 cases a diffusely infiltrative type 4 carcinoma was diagnosed but this diagnosis proved to be incorrect in not less than 7 cases. In 3 of these cases a type 3 carcinoma was found in the gross specimen and this mistake does not seem to be a serious one since the prognosis of type 3 and type 4 carcinomas probably is not very different. However, in 4 cases a type 2 carcinoma proved to be present and this is a mistake which should be taken seriously. There is no doubt that the type 2 carcinomas on the whole give a splendid surgical prognosis and certainly it is better not to try typing at all at gastroscopy than to mistake a favorable type 2 carcinoma for an unfavorable type 3 or 4 carcinoma.<sup>1</sup> This experience will caution us to be more careful with the diagnosis of gross types at gastroscopy and to undertake such a diagnosis only if the tumor is seen so completely that no doubt can possibly exist. Since the question of the prognosis of the different types has not yet been settled satisfactorily, the surgical action was not undertaken under consideration of types, all carcinomas were treated in the same way so that no harm was done by the incorrect gastroscopic interpretations.

<sup>1</sup>Thus in this series type 1 carcinoma was found in 2.7 per cent, type 2 in 17 per cent, type 3 in 29.7 per cent, and type 4 in 40.6 per cent of 74 cases.

## SUMMARY

1 In 95 cases of gastric tumor gastroscopic were compared with surgical findings.

In 5 of 91 cases of gastric cancer the lesion was not seen and in 5 other cases the lesions seen were wrongly interpreted. A sarcoma was mistaken for a polyposis, one benign submucosal tumor and one benign mucosal tumor were diagnosed correctly, one benign mucosal tumor was called cancer at gastroscopy. It is believed that the number of gastroscopic failures can be reduced with increasing experience. In 4 cases the gastroscopist did not commit himself as to the nature of the lesion.

2 In 3 cases of this series gastroscopic examination revealed lesions not palpated or seen by the surgeon at laparotomy. Further examination proved lesions to be present.

3 X-ray and gastroscopy will yield the best results in the diagnosis of gastric tumors when used together. In our series of 91 carcinomas 15 failures at the first x-ray examination are compared with 10 failures at the first gastroscopic examination.

4 The size and the site of the tumor were determined satisfactorily by gastroscopy.

5 The gross type of carcinoma should be diagnosed at gastroscopy only if whole circumference of tumor can be seen, and examiner should be careful not to diagnose a diffusely infiltrative type instead of a sharply limited tumor.

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# POSTTRAUMATIC DYSTROPHY OF THE EXTREMITIES

## Sudeck's Atrophy

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**I**n a previous communication (1) one of us (G. de T.) studied a few cases of vasomotor and trophic disturbances which were interpreted as being due to an abnormal nutritional reflex originating from the site of injury or infection and persisting for months and years. Rightly this syndrome should be named Sudeck's atrophy as this author clearly described it in 1900 in 1931, and again in 1938 (35). Since his original description, however a variety of names has been used to designate the same syndrome such as acute atrophy of bone traumatic angiospasm, chronic traumatic edema, peripheral trophoneurosis posttraumatic osteoporosis and reflex nervous dystrophy (11). Obviously the authors have focused their attention to different manifestations of the same syndrome in the bone in the vessels and in the nerves. Its resemblance to causalgia has also been pointed out (11) and recently Homans has reported some instructive cases under the name of minor causalgia. While Sudeck's name is rightfully associated with this condition he himself preferred to omit his name atrophy is not a typical feature of the disease in its earlier stages.

In this report we wish to present further clinical data on this vaguely understood and often unrecognized syndrome. A group of clinical cases has been studied with special emphasis on plethysmographic readings giving information on changes in blood flow to such extremities. Finally an interpretation of these findings has been attempted with some hints in regard to the prevention of this disabling clinical entity.

## THE INCIDENCE OF POSTTRAUMATIC DYSTROPHY

A vague syndrome such as this is frequently unrecognized especially in its milder forms. For this reason it is very difficult to find reliable data in the literature on the incidence of posttraumatic dystrophy. Shoemaker has searched a large material for the symptoms and signs of this disease found an incidence of 5 per cent among 500 cases of sprains. Certainly since our attention has been focused on Sudeck's atrophy many cases of minor severity have come to our attention. It is our belief that the early recognition of the peculiar reflex originating from the site of trauma may successfully abort the late sequelae and the long lasting disability by instituting prophylactic and ample therapeutic measures to be discussed below.

## THE NATURE OF THE REFLEX

In 1866 Christian Loven described a reflex which since bears his name. In stimulating the posterior auricular nerve of the rabbit he found a vasodilatation in the ear on the same side. This in turn could be prevented by cutting the cervical sympathetic trunk. He also found that when a peripheral nerve in the hindleg was stimulated the volume of the limb increased. Bayliss studied the Loven reflex and found that the dilatation was due both to the excitation of dilators in the dorsal roots and the inhibition of constrictors in the sympathetic outflow. He published convincing graphs to this effect some of which were republished in our first communication (1).

A study of these curves reveals however that the Loven reflex, consisting of active vasodilatation and edema of the limb, may be elicited in the absence of the sympathetic innervation. This would indicate that neither

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the afferent nor the efferent arc of the reflex need go through the sympathetics. This point must be emphasized because, as will be shown in the study of our clinical cases, increased blood flow, which is one of the cardinal symptoms of the first phase of reflex dystrophy, is not abolished after sympathectomy but persists even though the pain disappears.

Attempts have been made in the past to construct diagrams for such reflexes. Andrews saw the temporary disappearance of edema following radical amputation of the breast, when section of the posterior roots was done for intractable pain. In his diagram the vasomotor reflex arc is led through the sympathetic chain to the posterior root ganglion and from there into the posterior horn, the efferent pathway was led through the anterior roots joining the vessels through the sympathetic nerves. Middleton too believes that there are afferent, sensory fibers in the sympathetics. Yet, until disproved, the experiments of Moore and Singleton have yielded clear cut evidence that painful stimuli from the arteries of the extremities are mediated only by somatic nerves. In man the observations of Foerster and that of Leriche are often quoted to indicate that under a spinal anesthesia, with blocked somatic nerves, pressure or ligature of arteries may still be painful. Repeated personal experience has shown, however, that arterial punctures are painful in the sympathetomized extremity, it is reasonable to assume that vascular sensitivity is mediated by somatic nerves.

It has been common physiological teaching that the stimulation of peripheral nerve is more apt to lead to vasodilatation (i.e., to a Lovén reflex) when the nerve has been cooled previously, when it is in a state of regeneration or when the stimulus is weak. Otherwise, stimulation of sensory nerves usually elicits a pressor effect. Ranson and Billingsley explained the difference in vasomotor responses elicited by weak or strong stimulation by the variations in the resistance to afferent conduction. According to their findings weak impulses reaching the spinal cord are conveyed upward in the depressor path, namely in ventral paths of lateral funiculi containing long fibers with few relays, and result in vasodilatation.

The Lovén reflex then is a form of a defensive phenomenon by means of which an organ or a limb provide themselves with a better blood supply at the expense of the rest of the body. Its afferent arc is no doubt supplied by somatic sensory nerves, but much speculation may arise as to the mode of efferent vasodilatation. The posterior root vasodilators have been called "antidromic" sensory fibers by Bayliss, who believed that they carry impulses in both directions. But evidence has been accumulating that there are vasodilator efferent fibers in the dorsal roots, whose cells lie in the dorsal root ganglions and which are accessible to reflex activation via synapses within the cord (5). Such parasympathetic efferent fibers may truly be the "trophic" nerves of the older authors as their excitation produces vasodilatation and because their excitation mostly occurs as a reflex phenomenon. A herpes zoster is an example of a stimulation of these vasodilator efferent fibers, the stimulation here is due to a vascular or inflammatory lesion of the posterior root ganglion.

Reflex discharges over the dorsal roots were described by Gotch and Horsley in 1891. But their observations passed unheeded because they stood in opposition to the strongly entrenched law of Bell and Magendie. A study of Magendie's article reveals, however, that he did not suggest that sensory, afferent conduction was the only function of the posterior roots. The arguments for and against the existence of posterior root efferent fibers have been reviewed by Hinsey. Recently Toennies has shown conclusively that following the stimulation of sensory nerves in the cat, a reflex discharge takes place over the dorsal roots both on the homolateral and the contralateral extremity. The contralateral reflex is much smaller but lasts longer. A calculation showed that at least 35 per cent of the alpha fibers of the saphenous nerve were accessible to reflex activation.

Important from the standpoint of our clinical problem is the finding that facilitation of the reflex may be observed when a dorsal root to dorsal root reflex was augmented by the simultaneous stimulation of the sciatic nerve.

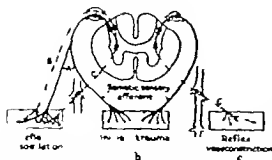


Fig. Trauma in the broad sense of the word may consist of mechanical, chemical, thermal injury, or vascular occlusion. Somatic sensory fibers carry impulses centrally from such an area. In A the nerve impulse never reaches the cord, but produces an afferent vasodilatation, mediated by posterior root efferent dilators (nociceptor nerves). In B the vasodilatation has been activated through spinal cord reflex. This pathway is postulated by Torrance but its existence is denied by Dole and Marston. In C vasoconstriction through activation of the efferent sympathetic fibers is shown. Vasodilatation may also occur through the sympathetic outflow. Contrary to the much emphasized reflex vasoconstriction following trauma or thrombosis, reflex vasodilatation is frequent and, if it persists, gives rise to chronic posttraumatic edema, osteoporosis, and burning pain. In carefully conducted animal experiments Albert (*Arch Internat. Physiol.* 934, 95) showed that all trauma results in vasomotor reactions which are most marked if articular or perivascular structures are injured. In the dog, at least these reactions are predominantly vasodilator, but there is spinal vasoconstrictor reflex. The vasodilator reflex is abolished only when peripheral nerve is sectioned and there has been allowed for degeneration. The vasomotor reactions in Sudeck's atrophy are the result of two opposing phenomena, both are vasoconstriction and vasodilation, the latter predominating at least in the early stages. Sympathetic block abolishes the reflex vasoconstriction and vasodilation through the anterior roots but does not block the axon reflex.

From a series of careful and painstaking clinical observations, Sir Thomas Lewis (23) was also forced to conclude that a set of nerves must exist outside of the somatic and sympathetic fibers which are responsible for a diffuse and widespread hyperalgesia which appears in many subjects around a point of faradic stimulation or a tiny crushing of the skin. These nerves, he believes influence cell permeability and cause a release of substances that produce itching hyperalgesia, and vasodilatation. Lewis named these nerves nocifensor and suggested that they belong to the posterior root system with efferent function. The flare around injuries and the burning vasodilatation are due to the stimulation of the fibers. As the reflex is not prevented by a nerve block central to the

point of stimulation but is abolished by injecting the nerve distally to the point of stimulation he believes that this is a peripheral effect within the distribution of a cutaneous nerve. This would be then a modification of the theory of an axon reflex, postulated previously by Lewis in the interpretation of the histamine flare (24).

Vasodilator impulses may reach the periphery however through the sympathetic nerves. J. H. Burn has reviewed the experimental evidence for sympathetic vasodilators. In man Lewis and Pickering (25) have shown that reflex vasodilatation obtained through heating the trunk is abolished in the sympathectomized extremity.

It has been justly emphasized by Burn that the distribution of vasodilators varies to various species of animals. Clinicians have been frequently confused by "cat physiology." It is necessary then to examine the evidence we have from clinical observations relating to the mechanism of inflammatory or reactive hyperemia.

An anesthetic limb such as results from a cut and degenerated peripheral nerve from a spina bifida or syringomyelia, shows a negative histamine flare, a lack of inflammatory rubor and heat following infection. Such anesthetic limbs frequently show trophic ulcers, which heal very slowly or not at all. The sympathetic pathway is intact but obviously does not contribute to a reflex vasodilatation. A sympathectomy for such "trophic" ulcers has never been of much benefit in our experience. An injury which, in addition to the soft parts, muscles, bones and tendons, produces a complete nerve injury has never been reported to produce the syndrome of reflex dystrophy. In this group of patients suffering from sensory anesthesia, the afferent part of the reflex arc is interrupted and so are the parasympathetic efferent vasodilators as they run in the mixed nerves.

A paralyzed limb such as a poliomyelitic extremity may show a normal circulation but about 25 per cent of our cases (unpublished data) show cyanosis, mottling, chilblains, pressure sores. Sympathectomy in such cases warms the limb and abolishes the painful crises in cold weather. Reflex dystrophy has

never been seen in this group. The vascular changes are probably due to changes in the lateral horn, or demyelination of the anterior roots, which may occur in poliomyelitis. The histamine flare and the reactive hyperemia are normal in such limbs.

The hemiplegic limb often shows an increased circulation early, owing to central sympathetic inhibition. Weiss and Ellis have studied such limbs in detail. In not a few cases there is a great deal of burning and throbbing pain in such limbs. It is customary to speak of a thalamic pain in such patients, with the admission that it is intractable. On the examination of such painful, burning, hemiplegic limbs, increased heat and osteoporosis may be observed. There seems to be a continuous vasodilatation present. If this is due to a mild chronic irritation of sympathetic centers or central pathways, a sympathetic block ought to give relief. Such an opportunity has not yet presented itself.

In patients with spinal arteriosclerosis, who concomitantly exhibit an obliterating arteriosclerosis in the extremities, there sometimes occurs a continuous burning pain with vasodilatation, a true erythromelalgia, which is aggravated by heat and improved by cold. All this may be present with pulseless arteries. Such nervous vasodilatation may be interpreted as an irritation of posterior roots or ganglia. A sympathetic block relieves the burning pain, a phenomenon which will be discussed in more detail later.

To summarize the reflex pathways which may be operating in reflex dystrophy, the afferent arc seems most likely to be in the somatic sensory nerves. It must be remembered that one of the earliest and most characteristic symptoms of Sudeck's atrophy is severe continuous or paroxysmal pain, the injury most frequently affects nerves, nerve sheaths, or periarticular structures, which are full of sensory receptors. The vasodilator efferent stimuli may go through the sympathetics but can be elicited in the absence of the sympathetic outflow, in which case they must be axon reflexes or spinal reflexes with an outflow through the posterior root vasodilators (Fig 1). The excitation of efferent vasodilators produces substances at the end

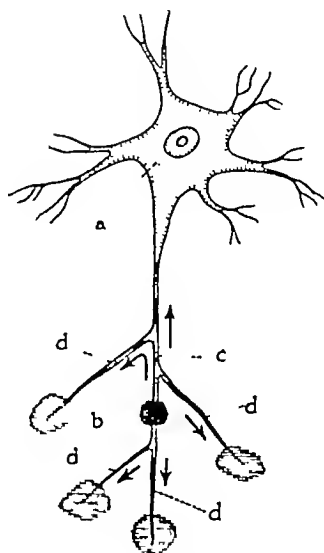


Fig 2 The axon reflex illustrated in Figure 1 is emphasized in this diagram. Its persistence and gradual spread is responsible in our opinion for the syndrome of Sudeck's atrophy. *a*, Is the ganglion cell in the posterior root ganglion. *b*, Is the site of trauma. *c*, Represents an afferent sensory fiber whose stimulation results in pain and a vascular reflex is mediated through the cord as shown in Figure 1. *d*, Are the efferent vasodilator fibers whose stimulation results in a secretion of vasodilator substances. The shaded areas around the nerve endings indicate this diffusible, humoral substance. This is a diagram of T. Guillaume, in *Le sympathique et les systèmes associés* published by Masson et Cie in 1921, which has been reinterpreted by us in the light of our present knowledge. In this diagram the stimulus is shown to spread centripetally to the next division whence it travels centrifugally, but it also travels in a centrifugal direction with the posterior efferent fibers. This type of spread would explain the observation of Tinel that blocking or sectioning of a peripheral nerve *distal* to the source of irritation may bring relief. This has been confirmed by Sir Thomas Lewis (23).

organs, which are responsible for both the vasodilatation and the pain (Fig 2). Ordinarily the choline-like substances, which are secreted at the end organs of parasympathetic fibers are rapidly destroyed, their persistence must either mean that the stimulation is continuous or that the esterase mechanism is defective (10). If this assumption is true, prostigmine or local acidosis definitely ought to aggravate the pain and vasodilatation of Sudeck's atrophy. This was true in Case 1 reported here.

The presence and gradual diffusion of this pain producing and vasodilator substance or substances confuse an orderly neurological examination. If the pain, hypoaesthesia or

hyperesthesia of the affected limb is of a glove or stocking type defying all patterns of segmental somatic innervation the neurologist will diagnose a functional disorder a state of mind or a compensation neurosis. This has been our experience with every case of Sudeck's atrophy referred for a neurological examination.

We shall discuss later the peculiar autonomic imbalance from which some such patients seem to suffer but simply wish to state here that mainly because of the chemical mediation of the cholinergic parasympathetic efferent fibers many neurologists simply ignore or evade this problem which not infrequently is presented before compensation boards.

#### THE DIAGNOSIS OF SUDECK'S ATROPHY

If the diagnosis of this syndrome had been made early enough many a long lasting disability would have been avoided. In studying the published reports in the literature and our own cases, we find that persistent pain of a burning character with paroxysmal aggravations presented by patients whose injury is properly immobilized, noninfected and seemingly on the way toward a normal course of repair should make one suspicious of an early beginning reflex dystrophy. In such a stage the extremity is warm shows increased oscillations, edema of subcutaneous tissues and joint capsule the muscles are hypertonic and are trying to splint the painful joint. There is no osteoporosis this finding does not occur unless 4 to 8 weeks of continuous collateral hyperemia have been present. The pain is rather closely limited to the site of injury and its spreading character is not evident. We have already stated that periarthritic structures are especially apt to give rise to such phenomena. Rauber (cited by Leriche) has counted 26 touch corpuscles around an interphalangeal joint. Nerves and blood vessels are equally apt to give rise to vascular reflexes when injured but while Leriche and his followers have always emphasized vasoconstriction as the most frequent vascular phenomenon following injury the burning pain of causalgia, the nutritional reflex of repair is a vasodilator phenomenon which

needs repeated emphasis and which will be demonstrated by our studies on blood flow.

The periarthritic edema which may spread for quite a distance beyond the joint is the second characteristic phenomenon encountered early. Of course traumatic edema may be due to direct injury to veins and lymphatics, to pressure of casts and dressings, to infection or even to artificial constriction in cases of malingering. The edema of Sudeck's atrophy however is well localized around the site of injury and at first it is warm and flushed. Weeks later it may become hard, cyanotic and cold to touch. Because of the splinting action of muscles and because of the synovial edema, the joints become stiff quite early and this is one of the most important residual disabilities with which one has to deal. Rheumatoid arthritis with vascular phenomena is quite analogous to Sudeck's atrophy.

There is finally an osteoporosis which, however does not occur until several weeks after the injury. There is a spotty decalcification of the small bones of the hand or foot and in the metaphysis of long bones where vascularity of the bone is the greatest. We are able to show two biopsy specimens of such bones. There can be no doubt about the cause of this decalcification being due to hyperemia. Pommer who has made a searching study of osteoporotic bone quotes Herman Meyer who first stated in 1853 that a rapidly developing osteoporosis always means a hyperemia in the affected bone. Pommer made the interesting suggestion that Sudeck's atrophy may be due to hematomas in the marrow with collateral hyperemia but without actual bone injury. We had no opportunity to confirm or disprove this hypothesis.

The mottled spotty bone atrophy later becomes diffuse at which time it is indistinguishable from osteoporosis of other origin, such as the ones due to inactivity, senility, undernourishment, biliary fistula and so forth. It must be emphasized that the diagnosis of Sudeck's atrophy should not be made on the basis of roentgen films. The syndrome may be present without it or it may be subsiding when the bone changes are at their height. Nor does the pain follow the course of



Fig 3 Films of F H, a 29 year old Mexican laborer, who suffered a fracture of the small bones of the left foot 15 months previously. Later a deep venous thrombosis developed. Causalgia symptoms appeared when weight bearing was resumed. Compensation neurosis was present. Gradual resumption of weight bearing, however, started recalcification. Note the coarse trabeculation in the heads of the left metatarsal bones. This case is typical of a Sudeck's osteoporosis complicated by atrophy due to disuse.

osteoporosis, because after sympathectomies the pain may rapidly subside but the osteoporosis persists for many months. The greatest value of roentgen films lies in serial examinations. When coarse trabeculation occurs with evidence of recalcification, the peak of disability has been passed. Complete restitution of structure has not been seen in our films.

#### DIFFERENTIAL DIAGNOSIS

The syndrome of Sudeck's atrophy may be so vague at first and clouded by additional complications later that its differentiation from other conditions is not always easy. In fact, the point should be made that it is often associated with the syndromes from which some authors try to separate it.

From the roentgenological standpoint and because of its frequency *atrophy of disuse* should be considered first. Atrophy of disuse is painless and not associated with marked vasomotor phenomena and certainly not with vasodilatation. Bone atrophy in the film is diffuse, comes on slowly and improves on the



Fig 4 Case of A McG. Left, normal control, right, tuberculosis of the ankle joint with marked bone atrophy. Note the destruction of the talocalcaneal joint.

assumption of active motion or weight bearing. It is our strong conviction that the early, spotty atrophy of Sudeck caused by increased blood flow to the bone and appearing within a month or so after the initial trauma is complicated later by a *superimposed* atrophy of disuse. At this stage a roentgenological differentiation is impossible. If the extremity can be made painless by procaine injections and adequate immobilization, the resumption of weight bearing and the active exercise of the surrounding musculature will hasten recalcification (Fig 3).

*Bone atrophy due to inflammation of joints*, such as tuberculosis, may show increased blood flow, continuous pain, edema, and deformity. But the destruction of the talocalcaneal joint, seen on the right, leads to the diagnosis (Fig 4). It may well be, however, that the bone atrophy seen around tuberculous and rheumatic joints is caused by the same vasodilator mechanism, which operates in the traumatic atrophy.

*Aseptic necrosis of bone* following vascular occlusions causes a rarefaction of bone, most visible in the vascular areas. Figure 5 shows such a film following the ligation of the brachial artery for a traumatic aneurysm. The necrotic areas do not have the same ground glass appearance as that seen in the acute traumatic atrophy of bone. The circulation, of



Fig. 5. Case of O. H. The brachial artery is ligated for traumatic aneurysm weeks prior to our examination and the taking of the films. Note the superior bone density of the carpal bones and the metacarpals of the phalanges. The shafts of the phalanges are dense. The picture is entirely different from that of Sudeck's atrophy.

course is greatly diminished instead of being increased.

*Senile osteoporosis* involving primarily the trabeculae of spongy bone is most evident in the vertebrae but it does involve other part of the skeletal system. In 3 of our cases (case 4, 5 and 9), there was a diffuse osteoporosis of the spine far from the site of injury. It has been our impression that in such cases the local posttraumatic osteoporosis was more severe and in addition less responsive to treatment (Fig. 6).

Other form of osteoporosis due to hyperparathyroidism, hyperthyroidism, pituitary basophilism and adrenocortical syndromes, metastatic malignant lesions, multiple myeloma and osteomalacia have been discussed and differentiated from senile osteoporosis by Black, Ghormley and Camp. They can hardly be confused with Sudeck's atrophy.

The so called *traumatic flatfoot* which produces a great deal of pain on weight bearing and because of lack of weight bearing may produce bone atrophy must be differentiated from an ankle sprain with immediate intractable pain, hypertonic and later atonic musculature with decalcification. Such a case is illustrated in Figure 7.

*Traumatic neurosis* comparable to neurosis, and malingering may have to be considered when patient are seen quite early. That the anxiety state of a patient may have a bearing on his autonomic reflexes is more than likely. In dogs lesions in the motor area are usually followed by dilatation of vessels in the corresponding extremity indicating that the dominant vasomotor representation in this part of the dog's cortex is vasoconstrictor (30).

Margaret Kennard removed the premotor area in monkeys and found that the mechanism for reflex vasodilatation was completely paralyzed. When such an animal was placed in a warm atmosphere the normal extremities showed quick vasodilatation but the affected extremity showed no such adjustment and remained much cooler than the control side.

In man the hemiplegic extremity shows interesting disturbances of heat regulation which have been studied in Bucy, Kern and Underwood, Pilcher, Wyatt and Lamer (39). The latter 3 authors demonstrated a unilateral overactivity of the sympathetic nervous system following a large infarction involving the distribution of the left middle cerebral artery. They interpreted this as a release phenomenon from cortical inhibition.

That autonomic reflexes are under cortical control is further exemplified by the work of Hesser, Langworthy and Kolb who after decortication showed greater strength and consistency of gastric contractions. The stretch reflex showed delayed relaxation. They felt that reflex gastric activity is demonstrably controlled by cortical action.

From a standpoint of therapy all these disturbing cortical and subcortical influences should be eliminated as much as possible. Early settlement, reassurance and relief from anxiety are all important before the local treatment is to be effective. Again it is our feeling that instead of trying to differentiate Sudeck's atrophy from a state of mind the participation of this element should be ascertained as it probably plays a rôle in the symptoms of any injury.

A hard, traumatic edema of the hand is sometimes artificially produced by a constricting band. The constriction may not be visible the naked eye at the time of examination but



Fig 6 Case of R. H. aged 71. Marked osteoporosis 15 months after injury of soft parts. This is Case 1 of our tabulated series. Severe osteoporosis of the spine was present.

if an infrared picture is available, it will show subcapillary extravasations in the form of a band (12).

#### THE COURSE OF THE DISEASE

There are mild types of reflex dystrophy which subside spontaneously in a few weeks or rapidly respond to treatment to be outlined. There are cases with moderate severity, causing complete disability, continuous pain, increasing contractures of tendons and joints and marked decalcification of bone. They run a self-limited course, however, and may heal spontaneously within a year. Often they leave residual stiffness, deformity and contractures of joints in spite of a very small injury. There is, finally, a severe form which shows a spreading neuralgia, a spreading osteoporosis, and gradually a mental fixation on this intractable lesion. Such patients may request amputation and threaten or commit suicide. A functional and economic rehabilitation of this group is hardly ever obtained. They may end up in sanitariums or closed institutions.

The severity of the original injury does not seem to determine the course of the disease. As a matter of fact, severe trauma causing fractures of long bones and total transection



Fig 7 Diffuse osteoporosis especially of the calcaneus and the tarsal bones with flattened longitudinal arch and spastic muscles, 7 months after a sprained ankle. The foot was never properly immobilized. It was warmer than its fellow and swollen. Nonpadded cast with walking caliper relieved the pain and permitted weight bearing. Recalcification was incomplete after another 6 months.

of nerves and blood vessels does not seem to be followed by this dystrophy. Sprains, mild frost bites, burns, partial nerve injuries, venous thromboses, low grade chronic infections, are in the history of these cases. One has the impression, after studying these patients, that their autonomic nervous system is labile, and hyperreactive. Whether this is the cause or the result of the prolonged disability we have not been able to determine. Most patients have been subjected to a neuropsychiatric study and this will be referred to in their histories. There has been, however, no single pattern or type of personality which was found to be characteristic for this syndrome. One cannot help referring to animal experiments which show that autonomic reflexes are readily elicited when central release is obtained (8). Applied to man this would mean that certain emotional states, anxiety, fear, and also uncontrolled pain are capable of exaggerating normally rapidly subsiding vascular reflexes. This problem is now being studied.

#### THE PREVENTION OF SUDJOK'S ATROPHY

It is an interesting fact that men like Boehler, who strictly immobilize most injuries but encourage early weight bearing and active motion, have not seen or deemed worthy of mentioning the syndrome under discussion. In a small monograph, Karitzky has pointed out the importance of complete reduction of fractures, careful suture of torn muscles and tendons, and evacuation of hematomas to minimize the chronic stimulation from foci of



irritation. He especially emphasizes the surgical correction of torn muscles, tendons, and ligaments. In surveying our own material it has been obvious that minor injuries without injury to bone but affecting ligaments, tendons, and musculature are overwhelmingly present in the history of reflex dystrophies and large fractures, which are satisfactorily immobilized are hardly ever followed by vasomotor and trophic disturbances.

The early and adequate control of pain especially of pain which is hardly in keeping with the severity of the injury is the next important preventive measure. Leriche has advocated the infiltration of hematoma in acute sprains with procaine solution a procedure which some men follow in this country. This is a simple and efficient method to prevent an activation of autonomic reflexes through painful sensory stimuli if the block cannot be performed for any reason around the site of the injury a nerve block proximal to the area such as that of the brachial plexus or the sciatic or femoral nerve is equally effective.

Whether early periarterial sympathectomy (16) or repeated sympathetic block with procaine (22) are more effective is difficult to say. The local infiltration is certainly more readily available to every surgeon dealing with minor injuries.

The third and last preventive measure is one which we mention with hesitation although every experienced physician has made use of it for many centuries. Beside immobilization and relief from pain the alleviation of fear anxiety the reassurance of the patient and the avoidance of all factors which may lead to a conscious or subconscious prolongation of a painful syndrome should be attempted. There is no clear cut evidence that the posttraumatic emotional status of a patient can actually influence the local autonomic reflexes originating from an injury that it has an influence on the patient's reaction to

possible settlement. A number of our patients (Cases 5 13 18 23 27 28) have been regarded by competent neurologists as malingers or hysterics but it should be pointed out that the emotional status of the patient may actually influence his bodily reactions to injury. Thus the decorticated animal with an intact diencephalon, exhibiting sham rage shows many exaggerated autonomic reflexes. In man the typical histamine flare an aversive reflex is markedly exaggerated under pentothal sodium anesthesia, whose depressant action is mainly central (unpublished data).

#### THE TREATMENT

As soon as an abnormal prolongation of pain, collateral hyperemia muscle spasm, and fixation of joints is discovered an attempt should be made to depress or interrupt the vascular reflex. If the site of irritation is clear such as the presence of a partial nerve injury a neuroma of an amputation stump, a scar in which nerves are embedded, or an arterial or venous thrombus, these foci may be cured. A torn muscle or ligament should be carefully repaired. This does not invariably break up the vicious cycle especially if the syndrome is of several months or years duration. However in Case 16 the resection of an obliterated segment of the axillary vein promptly relieved the edema and the vasomotor phenomena. In Case 14 the stripping of the subfemoral vein was followed by complete relief of symptoms. In Case 23 the resection of a digital nerve which had been partially injured and acted as a trigger zone gave relief from the spreading neuralgia but returned a few months later and progressed until other measures were taken. Generally speaking our results with local excision of areas which were suspected of serving as chronic stimuli were

mobilized Colles' fracture one may see an involvement of the dorsal interosseous nerve with a typical trigger zone giving rise to severe reflex dystrophy (Case 24). The resection of this nerve has been suggested by Turner, however, it has been found unsatisfactory by Middleton.

Repeated local infiltrations of procaine and repeated injections to the paravertebral sympathetic chain as advocated by Leriche have given temporary relief and allowed the patient to tolerate physical therapy. It was found that if the patient received a block of the sympathetic chain the joints would loosen up, the muscle spasm would relax and in this state heat, gentle massage and active motion would bring about greater improvement. The repetition of this procedure two to three times a week has brought on great relief in Cases 20, 27, and 28.

In the later cases in the presence of much atrophy and contractures, a sympathetic ganglionectomy was done (Cases 4, 7, 8, 12, 17, 29 and 31). In certain patients (Cases 7, 12, and 17) this resulted in permanent relief from pain, although the contractures irreversibly remained. In others the neuralgia returned, spread higher and the pain became intractable. In such patients, posterior root section or chordotomy may fail as the source of the pain now has become thalamic. A surgical excision of the sensory areas in the cortex has not yet been done. Such patients often commit suicide and most of them become morphine addicts.

In summarizing our methods of treatment, they vary with the severity of the disease and with the stage in which they are seen. When the syndrome is recognized early, infiltrations of procaine are most helpful. If this fails or if the disease is of several months' duration, repeated procaine blocks of the paravertebral sympathetics have been done. Should this fail, a sympathetic ganglionectomy is indicated. Section of sensory nerves, dorsal roots or the spinothalamic tract has not been as useful as the interruption of the sympathetic fibers. Much attention is to be paid to the mental status of the patient. If there is a law suit pending, it should be settled at the earliest possible time.

#### STUDIES ON BLOOD FLOW

Several methods of determining blood flow in man have been described. While none of the methods is devoid of errors, we believe that the procedure of Abramson, which one of us (D S M) has slightly modified, has eliminated many of the defects inherent in plethysmographs which operate by air instead of water displacement.

Our method of study was briefly as follows: the patient came to the laboratory early in the morning without breakfast. He was placed comfortably on a bed and rested for 30 minutes covered with a light woolen blanket. The temperature of the room, unless otherwise mentioned, was 28 degrees centigrade, the humidity was not controlled. The temperature of the water bath, in which the extremity was placed, was 32 degrees centigrade except in some studies in which cool and hot environmental effects were studied. A specially constructed plethysmograph was used in all observations (Fig. 8).

The principle of the machine, as that of all other plethysmographs, is to detect a volume change in the extremity by means of an occlusive pressure placed at the site of the insertion of the extremity into the machine. This occlusive pressure, for the upper extremity was 70 millimeters of mercury, and for the lower extremity 120 millimeters of mercury.

The amount of occlusion, however, may be varied for different individuals, as has been discussed by Abramson. The change of volume of the extremity, produced by a sudden occlusion of venous outflow while the arterial inflow continues, is transmitted by a single system to a Brodie's bellows. This change in volume is recorded on a moving kymograph, by means of a small ink through which a small piece of hypodermic needle is inserted. A timer was used.

The apparatus can be used for the arm, hand, or foot. It has an entrance and an exit of equal dimensions, although one end can be closed securely by a special metal flange. The hand, foot, or forearm, after insertion into the machine, is surrounded by a rubber cuff which is glued in place by rubber cement. The hair is shaved off of the extremity, before insertion. The proper cuff is used with special care to prevent either constriction of the superficial vessels or to prevent the application of a very loose cuff which would allow leakage. This cuff is applied over the inner metal protrusion and secured in place by a monel metal ring with a large thumbscrew, which is used for tightening to prevent any water leakage. Horse saddle felt, one half inch thick, is placed between the rubber dam and the outer metal plate after the extremity is inserted. This immobilizes the hand in place rather securely. The hand or foot rests in the double cylinder comfortably on a copper sling so that the extremity is not in contact with the sides of the inner walls. For the hand or forearm the double cylinder is used, whereas the

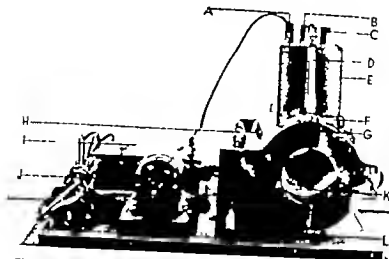


Fig. 8. Final design of plethysmograph the result of several modifications. A insertion for electroregulator. B outlet leading to kymograph. C outlet for thermometer. D indicator to show the amount of water present in the plethysmograph. F cubicle for foot. F thermometer (attached to metal ring to tighten rubber dam). G, metal panel enclosing hand or foot. H plunger to calibrate blood flow after each determination. I swirl block. J motor. A suspension for extremity. L, outlet.

Cylindrical top of the plethysmograph has been applied to the foot and may take foot up to size twelve in relative comfort. An electric stirrer with four blades attached through the middle of the machine by coupling rod to motor with reduced gear and an electric heating element directly attached to thermostat the machine are placed in small metal cubicle off to one side of the main plethysmograph. They are in direct contact with the water that surrounds the limb. The fan is routinely turned on for all experiments, whereas the heating element is used when an elevated temperature is necessary. The fan distributes the water after the heating element is turned on so that one may be sure of constant uniform change in temperature at all times. There are three openings on top of the machine.

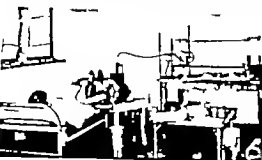


Fig. 9. Blood flow determination on the right hand. The kymograph with ink recorder is to the right.

One is used for thermoregulator. The second opening, the largest one which is 1 inch in diameter is the center directly connects the machine to the volume recorder. The third opening is used for the insertion of small thermometer. One may read the temperature of the water at any moment during the experiments. Water at 35 degrees centigrade is added to the machine through one of the top openings. The machine must be entirely filled and tapped gently to release any hidden air bubbles that may occur in one of the four corners of the upper cylinder of the apparatus. When the extremity is surrounded with the cuff and secured by cement, attached to rubber dam (1/4 inch thick rubber) it is then secured by the metal metal ring, tightened by thumb screw to prevent water leaks and again reinforced by the felt and the special metal plates. The machine now after filling the water is read to be used for determinations of blood flow. A small blood pressure cuff of 5 centimeter width is placed about the extremity close to the entrance of the machine. The cuff is directly attached to mercury manometer which has been previously calibrated and which indicates the amount of occlusion applied. The motor is turned on, rotating the fan, and the thermoregulator adjusted necessary to change the temperature of the water. From 5 to 7 minutes are usually required for every 5 degree increase in temperature of the water. The subject for the experiment is all covered, exposing only one extremity at a time, the other being kept covered during the time of the experiment. Absolute rest is imperative and no external stimuli should interfere with the patient.

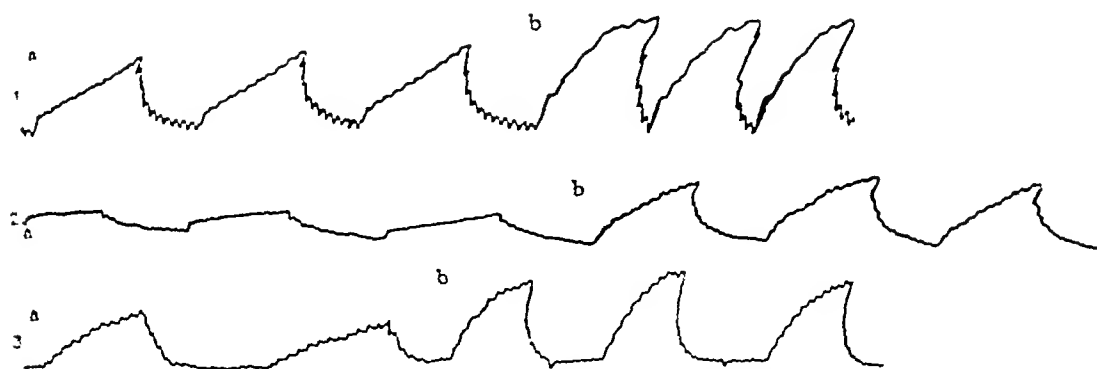


Fig. 10. *a*, *c*, D (Case 15). Blood flow left normal hand. Nine trials averaged 3.4 cubic centimeters blood per 100 cubic centimeters limb volume. *b*, Blood flow in involved hand. Ten trials averaged 5.0 cubic centimeters blood per 100 cubic centimeters limb volume. *2a*, R. D. Case 8. Blood flow left normal foot. Nine trials averaged 2.15 cubic centimeters blood per 100 cubic centimeters limb volume.

*2b*, Blood flow involved foot. Six trials averaged 5.6 cubic centimeters blood per 100 cubic centimeters limb volume.

*3a*, B. S., Case 6. Blood flow right normal hand. Ten trials averaged 2.01 cubic centimeters blood per 100 cubic centimeters limb volume. *b*, Blood flow involved left hand. Fifteen trials averaged .9 cubic centimeters per 100 cubic centimeters limb volume.

during the course of the experiment (Fig. 6). A 30 minute rest period is allowed before each test and 60 seconds and intervals are allowed between each succeeding occlusive pressure. The position of the extremity is most important. For the lower extremity the patient lies comfortably in bed, the hip abducted to 15 degrees and the leg and foot elevated about 4 inches above heart level. All muscles are in a relaxed position. For the upper extremity the shoulder is abducted to 70 degrees, the elbow flexed to 120 degrees and the hand kept either in pronation or in supination/pronation, as this is the most comfortable position for the patient to assume for pro-

longed periods. Special blocks with grooved out areas for the reception of the calf muscles, as well as blocks for the humerus have been made to elevate the lower extremity comfortably before entrance into the machine. A small pillow is used for the head and neck.

Each determination included a blood flow reading on the normal, opposite extremity. The cuff was placed at exactly the same position and exactly the same location as the normal extremity. It was important to determine whether there was any occluding pressure before the test was made by detecting any change in color of the extremity or by

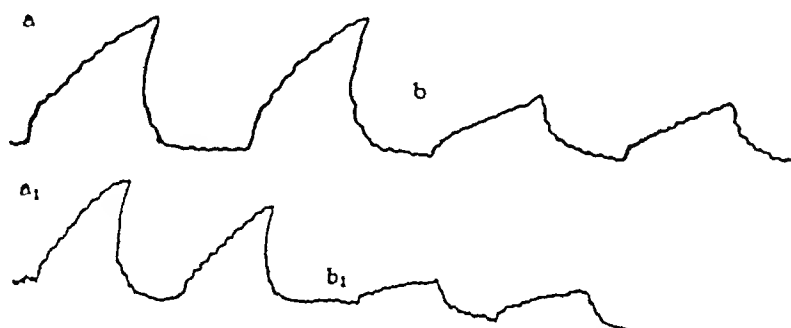


Fig. 11. K. H. Case 1. This chart indicates that within the normal and involved hand with respective blood flow response to decreased temperature of the water medium (15 to 17 degrees C.). Blood flow involved right hand averaged in 7 trials 8.7 cubic centimeters of blood per 100 cubic centimeters of limb volume. Exposure to decreased temperature of 22 degrees, 10 degrees we used water 22 cubic centimeters of blood per 100 cubic centimeters of limb volume. Blood flow of normal left hand in 11 trials averaged 5.1 cubic centimeters blood per 100 cubic centimeters of limb volume. Blood flow of involved right hand in 13 trials averaged 1.8 cubic centimeters blood per 100 cubic centimeters of limb volume. Water temperature of 15 to 17 degrees C. water temperature of 22 degrees C. (blood per 100 cubic centimeters of limb volume). Note that the normal extremity is able to function properly in the presence of the involved extremity.

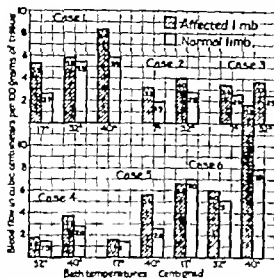


Fig. 1. The effect of temperature on blood flow in troley.

the complaint of the patient. The machi as allowed to run for several minutes to determine standard base line. Arteries were watched for and were detected during the course of the experiment and results obtained therefrom were tested or corrected. Sudden rises in the curve too flat plates or various dips or sudden elevations in the curve meant either defect in the machine leak in the system or movement on the part of the patient. The patients were told not to cough, sneeze or move. They were also told not to fall asleep or move their other extremities in any way. Leaks were the most annoying problem but could be controlled with exact application of the rubber to the rest or tube and proper closure of the constricting ring over the inner tube of the machine. The usual curve as that of a slow rise and relatively flat plateau after some time elapsed following occlusion of the distal extremity (Fig. 1 and 2). Pulse waves, as seen on the kymograph were absolutely necessary to determine the state of the machi. Calculations are made on the determined curves by projecting cubic centimeters of tetrodotoxin to the system through needle and rubber tubing to the exit of the machine. Another injection of the same quantity of water as well as third if this is necessary, was made to calibrate the flow of blood as determined by the rise of the curve. These injections were made because it was found that the apparatus was sensitive to different degrees at different levels of the curve.

The results are calculated in cubic centimeters of blood per 100 cubic centimeters of limb of the. From 6 to 20 trials were made on each extremity and the average taken from them. The room

TABLE 1.—STUDIES OF BLOOD FLOW IN POST-TRAUMATIC REFLEX DYSTROPHY

Case	No. of needles	Blood flow in per cent of limb volume		Limb volume in		Per cent increase in blood flow (affected limb)
		Affected limb	Normal limb	Affected limb	Normal limb	
R. F.	13	85		61.5		+
S. O.	10			100		
P. O.				107.5	10	
A. W.				100	100	
M. B.		35	10	113	104	
G. S.		47		100	100	
C.				107	100	
S. R. D.		2		100	100	+
E. L.		67		115		
M. B. W.	20	86	60	100	100	
M. S.		20	10	115	100	10
O. D.				11		
Total		41.26	3.21	700	4.71	

temperature bath temperature and blood pressure were noted at each sitting.

Aside from the plethysmographic studies, oscillometric readings were done in all subjects. Fickson oscillometer was used. Temperatures of the digits and of the toes were made for comparison. Studies in some cases before and after sympathectomy. A General Electric apparatus was used for these determinations. Blood chemistry studies, calcium, phosphorus and phosphate, total proteins and uric acids were determined. Also uric acid and blood counts were done at the same time. Injections of the at flat ganglion and lumbar paravertebral chains were made through catheters, usually before operation to determine the effect of blocking the vasomotor response to the extremity.

#### RESULTS OF BLOOD FLOW STUDIES

A total of 114 determinations were made on the affected and the same number on the opposite extremity of 12 patients. Table 1 shows a brief summary of our findings. It is noteworthy that in 11 of 12 patients there was increased blood flow in the affected limb, varying from 60 per cent to as little as 5 per cent. The volume of the affected limb was also usually larger although this increase did not by any means parallel the marked increases in blood flow. The only patient who showed a decreased flow in the affected limb was C. B. Case 7 who had a very small rest

ing blood flow and who, as a subsequent sympathectomy showed, must have had marked peripheral vasoconstriction. While his basal metabolic rate is not available, his clinical findings were those of a hypothyroidism which is usually characterized by decreased blood flow through the extremities.

In Case 5, in which there was no definite increase in blood flow, the following status of the affected extremity was found: the first determinations of blood flow were made 10 months after a fracture of the fibula, which was immobilized in an equinus position. The affected extremity showed marked trophic changes. The skin was shiny and atrophic, the nails were ribbed, and the ankle joint was swollen. There was also some increase of hair on this extremity. In the 12 blood flow determinations, the average of which is given in Table I, 6 gave a higher and 6 gave a lower reading than that of the control extremity. All readings were quite low. This patient no doubt represents a late stage of Sudeck's atrophy with marked organic changes.

C B, Case 7, had an automobile injury to the left ankle, following which no fracture could be demonstrated. The basal blood flow of this patient was exceptionally low, although he was not arteriosclerotic and only 37 years old. He was always cold, wore heavy underwear always, and responded poorly to decreases in environmental temperature. Unfortunately no basal metabolism test was obtained. In 9 of the 12 determinations the blood flow was higher on the affected extremity, but most of these were done after a lumbar sympathectomy. The average reading of the 4 determinations done before sympathectomy was only 1 cubic centimeter per 100 cubic centimeters of limb volume, this being the lowest value obtained in this series and closely approximating the blood flows obtained by us in advanced obliterating arteriosclerosis.

With the exception of these 2 cases, there was a definite increase in blood flow of the injured extremity. The average increase of the 12 cases was slightly over 30 per cent. This remarkable increase, persisting over many months or several years after the injury, is the most characteristic feature of the syndrome.

TABLE II—THE EFFECT OF SYMPATHECTOMY ON BLOOD FLOW IN REFLEX DYSTROPHY

Case	Blood flow in c.c. per 100 c.c. of limb volume			Number of determinations
	Affected limb		Normal limb	
4 K W	Before operation	1.0	1.43	6
	After operation	1.7	3.2	3
7 C B	Before operation	1	1.1	4
	After operation	2.69	1.0	8
S R D	Before operation	1.7	1.87	8
	After operation	3.52	2.4	5
12 G D	Before operation	5.1	4.06	5
	After operation	4.4	3.85	2
	Totals Before	11.7	8.46	23
	After	14.3	11.35	18

Its possible mechanism has been discussed under the heading of vasodilator reflexes. Of great interest was the behavior of such extremities when they were subjected to changes in environmental temperature, while the room temperature was kept at 28 degrees centigrade and the temperature of the water bath was varied from 15 degrees centigrade to 40 degrees centigrade. Figure 12 shows that at lower temperatures the difference in blood flow between the two sides was generally not as marked as at higher temperatures, but, in addition, the affected extremity did not respond with vasoconstriction as readily in a cooler water bath as did the normal limb. One would expect such findings in the presence of a chronic vasodilation, but, as pointed out, there is often a masked vasoconstriction in such limbs, which may account for the instability of response seen in Case 1.

#### THE EFFECT OF SYMPATHECTOMY ON BLOOD FLOW

Of several patients who underwent sympathectomy, we have blood flow determinations, before and after operation, on 4 (Table II). K W, Case 4, was seen 5 months after a fracture of the fibula and a severe sprain of the ankle. Severe, continuous pain occurred immediately. A cast was applied for 2 months. Because of the marked osteoporosis (Fig 13) and the early intractable pain, a diagnosis of Sudeck's atrophy was made by one of us.



Fig. 3. Severe diffuse osteoporosis in K. W. Case 4, 5 months after sprained ankle (ith. fracture of the tibia).

(D.S.M.) when seen 5 months after the injury. The bimalleolar space was widened and the foot was held in an equinus position. The ankle was cold, swollen and the skin was shiny. In 6 determinations of blood flow before sympathectomy there was an increase in 4 out of 6. There was a small plateau type of blood flow curve as seen in obliterative vascular diseases. The Wassermann reaction was strongly positive in spite of intermittent treatment with neosarsphenamine and flsmuth. Following sympathectomy there was an increase in blood flow in both extremities a finding which Leriche has indicated for many years. While the pain has disappeared and the patient has been able to bear weight on the extremity, the osteoporosis is still present and is even detectable in the knee and hip of the same side.

Case 7 C. B. has already been referred to as having a very low preoperative blood flow. The left injured ankle was much warmer than its fellow although it felt colder to the patient. Four readings were done before and 8 readings after a left lumbar sympathectomy. The bath temperatures were kept constant at 32 degrees centigrade. The postoperative readings were made from 1 day to 3 months after operation. The readings were consistently higher after sympathectomy. Clinically, the limb operated upon was dry, warm and pain on weight bearing disappeared.

Case 8 R. D. dislocated her left foot with a marked extravasation of blood at the ex-

ternal malleolus. Following reduction the foot and lower leg were placed in a cast for 6 weeks. Eight blood flows were done from 7 months to 21 months after the accident, indicating a marked increase on the injured side. Six blood flows were determined from 11 days to 4 months after sympathectomy. While there was complete relief from pain, the blood flows were not especially affected on the injured side where vasodilation was already marked.

Case 12 G. D. had been seen comparatively early, 10 weeks after an injury to the left ankle without fracture. While she was properly splinted continuous intractable pain developed immediately after the injury. The blood flows were high in both feet but distinctly higher on the injured side. After sympathectomy the blood flows decreased on the side operated upon and not on the control side. Clinically there was marked relief from pain. A shortening of the Achilles tendon had to be corrected by casts.

In summary, a total of 23 blood flows were done prior and 18 blood flows following sympathectomy. The interpretation of the paradoxical findings of the changes in blood flow in relation to the clinical improvement will be attempted in the discussion.

#### STUDIES ON CALCIUM METABOLISM

Blood calcium, phosphorus and phosphatase determinations were made on 12 patients affected with reflex dystrophy (Fig. 14). In 4 patients the determinations were made twice several weeks apart. While the calcium and phosphorus showed no deviation from the normal, the phosphatase was slightly but definitely elevated in most instances. The blood phosphatase level for the normal adult should not exceed 4 Bodansky units. The lowest figure of 4 units was obtained in Case 10 B. H. who suffered a blunt injury to the dorsum of the hand and developed a spotty atrophy of the carpal bones, not a great mass of bony structure. The highest reading of 10.4 unit was obtained in Case 9. This patient had a diffuse osteoporosis of the entire upper extremity which followed a fracture of the shoulder 6 years previously. This woman was 58 years old and her traumatic osteo-

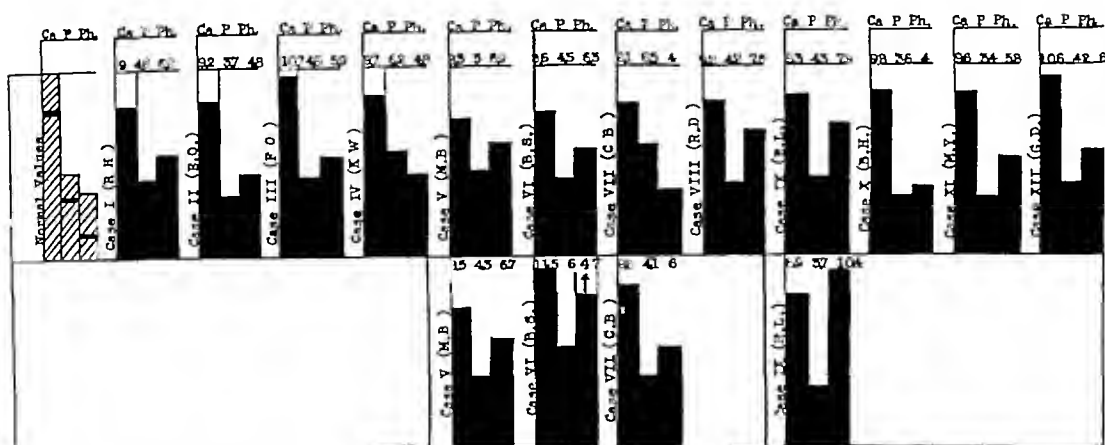


Fig 14 Calcium, phosphorus and phosphatase studies in Sudeck's atrophy Normal values calcium, 9.5—11 mgm per 100 c.c serum, phosphorus, 3.7—5 mgm per 100 c.c serum, phosphatase, 1.5—4 units (adult)

porosis may well have merged with a senile osteoporosis, a complication which will be discussed in our comments

There are not many control determinations on other forms of atrophy but from our figures, it would seem that there is some correlation between the extent of bone atrophy and height of the blood phosphatase level

#### BONE BIOPSIES

In K.W., Case 4, during a lumbar sympathectomy a biopsy specimen was taken of the lower end of the tibia. The original injury was a dislocated ankle with a fracture of the lower end of the fibula 5 months previously. The soft tissues were vascular when the bone was exposed. The bone was purplish-red in color and the cortex was very thin. This finding reminded us of the suggestion of Pommer, one of the foremost students of osteoporosis, that Sudeck's atrophy might be initiated by intramedullary hemorrhages. The medullary canal was unusually wide, on chiseling through the cortex a marked hemorrhage ensued which was finally controlled by pressure. The piece of cortical bone removed was extremely thin and fragile. The microscopic sections revealed a bone atrophy with reduced spicula. There was marked osteoblastic activity around each bone island and a marked increase in vascularity. The periosteum was intact and markedly thickened (Figs 15 and 16)

In E.C., Case 9, suffering from a reflex dystrophy of 6 years' duration, a biopsy specimen was removed from the lower end of the ulna. The initial trauma was a fracture around the shoulder joint. The cortex was thin and the medullary canal was wide, but only a moderate amount of bleeding was encountered. The histological section revealed a simple atrophy, no increase in blood supply and reduction of osteoblasts. Compared with the previous case, this was a late stage of Sudeck's atrophy (Fig 17), an atrophy of disuse

#### DISCUSSION OF CASES

We have detailed records on 33 patients whose essential data have been summarized in Table III. As discussed earlier in this paper, the diagnosis of Sudeck's atrophy was not made unless the following criteria were present (1) history of injury (or in some cases, vascular thrombosis), (2) almost instant, continuous severe pain, which does not subside in a few days and is out of proportion to the detectable damage to tissues, and (3) a spotty and later diffuse osteoporosis, which, however, is not present in the first 4 to 6 weeks after the initial trauma

The table reveals that no age is exempt. In a few older individuals, the differential diagnosis between a traumatic and a senile osteoporosis becomes difficult. In Cases 4, 5, and 9, x-ray films of the spine revealed a



TABLE III—REFLEX DYSTROPHY OF THE EXTREMITIES  
Essential Features in 33 Cases

Case	Age	Initial Trauma	Duration of symptoms in months	Treatment	Result
R.M.		Injured limb		Spon cast	Gradual improvement, not lost
E.O.	34	Sprained ankle	8	Molded splint	Gradual improvement, not lost
I.O.	60	Sprained ankle		Cass's paste by calipers	Partial relief
W.	49	Dislocated ankle fracture of tibia		Cast for seven months sympathetic	Marked improvement, not completely
M.B.	26	Sprained ankle and fractured tibia	24	Reduced	Total disability
S.		Fracture of navicular bone	18	Cast, immobilization of elbow, shoulder	Gradual improvement
C.B.	37	Sprained ankle		Limbic sympathetic	Excellent
B.D.	27	Dislocated ankle		Reduction, cast, 25 days limbic	Excellent
T.L.	35	Fractured shoulder	78	Immobilization, permanent sympathetic	Improved
16 H.H.	20	Sprained wrist		Strapping, surface block	Excellent
M.V.	35	Sprained ankle		Cast	Unknown
O.D.	30	Sprained ankle		Spinal, limbic sympathetic	Excellent
J.O.	18	Wrist injury of wrist		Posterior 25 sympathetic	Excellent
J.N.		Deep periphallus	24	Strapping of wrist	Excellent
D.R.		Knuckle phallus	24	Reduced	Unknown
18 H.R.	23	Thrombosis of wrist		Strapping of wrist	Excellent
17 B.W.	3	Infection and necrosis over lower ankle		Limbic 25 sympathetic	Relief from pain, not cure
E.H.	20	Wrist injury at wrist	24	None	In State institution
19 R.C.		Sprained ankle		Cast, strapping	Poor
20 E.D.	35	Sprained wrist		Surface block, 25 sympathetic	Excellent
J.S.	20	Crushed 1st finger		Alcohol block to relieve	Excellent for some recovery
C.	25	Crushed 1st finger		Repeated pericard block	Yes
B.H.	25	Fractured phallus		Posterior 25 sympathetic	Good recovery
J.	40	Calf fracture, poor reduction		Repeated local and surface block with procaine	Yes and less
H.M.	30	Refractory of forearm of hand		Limbic sympathetic	Excellent for some recovery
16 W.	32	Deep thrombophlebitis fracture of tibia bone	20	None	Unknown
17 D.H.	20	Blunt injury to forearm of hand		Repeated local and surface block	Excellent
18 L.	34	Blunt soft tissue injury to forearm of hand		Repeated surface block	Excellent
19 J.	27	Blunt injury to arm on face		Spinal hypodermic limbic sympathetic	Excellent
20 J.D.		Sprained ankle		Posterior 25 sympathetic support incomplete sympathetic	Yes
C.	60	Crushing injury to lower leg		Anterior hypodermic limbic sympathetic	Excellent
H.J.	24	Sprained ankle		Alking cast	Excellent
B.		See following account of case		None	Probably evaluated

\*Case 16 have been described previously (J. Surg. 1917, 24, 90)



Fig 15

Fig 15 Photomicrograph of lower end of tibia in the case of K W. The general structure is that of bone atrophy although the adult bone cells may be seen in the tissue. There is evidence of degenerative nuclei in some bone cell spaces.



Fig 16

Fig 16 Photomicrograph of case of K W near the marrow cavity. Bone cells may be seen adjacent to the



Fig 17

marrow. This section indicates a more active section than that of Figure 15.

Fig 17 Case of F L. This is a bone section taken from the upper third of the ulna in a 7 year old case of Sudeck's bone atrophy. The bone is atrophic in nature, adult bone cells being seen in lacunar spaces with the nuclei at the periphery and with evidence of degeneration.

diffuse senile osteoporosis. Yet their local injury and the character of the spreading neuralgia from a comparatively small painful focus made the diagnosis of a traumatic dystrophy necessary.

In a case not tabulated because of meager data, a 12 year old girl, who suffered a fracture of the ankle with malleolar separation, developed an acute and quite extensive decalcification with severe pain both with and without weight bearing. This occurred in spite of the fact that she had been allowed early weight bearing with a walking caliper. Obviously the immobilization was incomplete.

In Cases 10, 20, 27, and 28, the syndrome was only a few weeks' duration. However, they were not mild cases. Cases 27 and 28 were under the close attention of one of us (G de T) and required a great deal of sedation before the procaine injection started. The local infiltration of procaine at the site of maximal pain seemed to alleviate the pain for a few hours. The block of the stellate ganglion gave more lasting relief, lasting for a week or more, the second or third injection usually stopped the process.

Cases 9, 13, and 23 had a periarterial stripping. Of these 13 and 23 were comparatively early cases. They both recovered but their recovery was slow and it is now our impression that these patients would have done better with repeated paravertebral injections of procaine. In Case 9, a difficult case of 6 years' duration, with a great deal of trophic

changes in the skin, tendons, and joints patient had only a partial benefit from this operation, which was done elsewhere.

Cases 14 and 16 had a perivenous stripping for venous thromboses which resulted in reflex vasomotor and neuralgic phenomena. Both patients obtained lasting (4 and 5 years') relief.

Cases 4, 7, 8, 12, and 17 had lumbar sympathectomies. In Case 4, the lumbar sympathectomy, done elsewhere, resulted in incomplete denervation, the area of greatest sensitivity showed extensive sweating. Nevertheless, she showed slow improvement. The 4 other cases had early relief from pain, in spite of the fact that vasodilation and osteoporosis remained for some time. These were complete sympathectomies. As all 4 were severe and late cases, the orthopedic management of joints and tendons needed special care. Two of the patients' ankles were in equinovarus position and were corrected by lengthening of the Achilles tendon and casts. All such secondary complications could, of course, be readily avoided by early management.

With the exception of a few injured shoulders, Cases 1, 9, and 29, in which injury to ligaments, tendons, and brachial plexus is so frequent, most of the injuries occurred at the hand, wrist, or foot and ankle, fractures were rare and mostly associated with ligamentous tears. In some instances direct irritation to nerve trunks was demonstrable. Thus, in Case 13, that of J G, whose wrist was

caught in a wringer exploration of the wrist revealed a perineural fibrosis of the median nerve. In Case 8 R D when she was examined 7 months after a severe sprain of the ankle there was a plantar anesthesia with a loss of position sense of the third, fourth and fifth toes. In the case of B H a farmer who drained an abscess over the inner malleolus, a small strip of hyperesthesia was present corresponding to the area of the saphenous nerve. In Case 24 J M C a poorly reduced Colles fracture must have injured the dorsal interosseous nerve as radiation of pain along its area of distribution could be elicited. In Cases 27 and 28 both patients suffered a mild injury to the dorsum of the hand and partial injury to the superficial radial branch was well established. In a case seen recently in consultation the area of the partially traumatized anterior tibial nerve compressed by a callus could be rasped out by a skin area of increased temperature. As these injuries were mostly partial and consisted of perineural hematomas or stretching their diagnosis could only be made when seen early after injury. The significance of these minor partial injuries to sensory nerves will be discussed under Analytical Comments.

#### ILLUSTRATIVE CASE REPORTS

##### *Early severe cases difficult to differentiate from psychoneurosis or hysteria*

D H Case 20 as a student nurse hospitalized mild bilateral injury to the dorsum of the left hand. The hand had been caught between a stretcher and cement all immediately severe pain developed. There was no fracture no evidence of soft tissue injury and no hematoma. Immobilization on splint for 2 weeks gave no relief. Physical therapy consisting of heat, turpentine, and massage gratified the pain. When seen 2 weeks after the injury the hand was slightly swollen. The rest and fingers were held rigid extension. The extensor muscles were spastic and permitted no movement. A few centimeters of pain was injected in the region of the dorsal interosseous nerve promptly relaxed the spasm the patient could close her fist readily. The effect could only last few hours after which the same rigid position was assumed. Daily injections of procaine in and around the same area gradually produced improvement of the hand but spreading pain developed in the region of the elbow and shoulder. These were controlled by two injections into the stellate ganglion. After 3 weeks of

treatment, the hand as palmar completely regained function and showed no swelling.

The patient patient or doctor had gained the impression he had no contact with the world died of a brain tumor. A roentgen examination revealed no visible individual and hysterical hand as suggested. The patient had many of the emotional complaints seen in psychoneurosis, irritability, bowel, and inability to sleep at times.

The differential diagnosis between true hysteria and an early reflex dystrophy seems impossible in this case. If the procaine injections acted were psychotherapy the approach seemed easy and the treatment short. A close check on her later behavior showed that there has been no recurrence of the syndrome for 6 months.

##### *Another early severe case is that of L S Case 27*

This patient hand as injured in streetcar accident. When seen 3 months later she as first urged to obtain settlement as compensation. Neuroses had to be ruled out. She as highly sensitive to low pain threshold, as demonstrated by the Libens test. There was no swelling, no tenderness of nerve injury and no fracture. There was however an exceedingly tender area just proximal to the wrist on the dorsoradial side. With pressure as exerted over this area radiation of pain as felt over the area of the superficial radial nerve both proximally and distally. There was much more spreading neuralgia in this instance than in the preceding one. The shoulder, the back of the neck and the anterior chest all were sensitive. Three injections of procaine into the second and third dorsal sympathetic ganglia relieved the pain. She as re-examined 3 months later and had no recurrence of symptoms.

Both of these cases were seen too early to show osteoporosis and neither was there any trophic change in the soft tissues. The osteometric curves and histamine flares however indicated an increased blood flow to the affected area, a partial injury or a perineural hematoma of the dorsal interosseous nerve was a distinct possibility. This is the explanation given by Turner many years ago for trophic lesions following Colles fracture. This mechanism reminds one of the hysterical ankle of some patients, who after a minor sprain complain of intense burning pain with paroxysmal aggravation and a proximally spreading neuralgia. We have seen such a patient but no study was made at that time of the patient's circulation.

*Early mild case*

B H, a 40 year old white male struck a man on the head with the palm of the left hand. Within a few hours marked swelling of the dorsum of the hand and wrist developed. X-ray films were negative for fracture. He received an adhesive tape dressing for 2 weeks followed by heat and massage at home. There was a continuous pain and burning which was relieved by cold and exaggerated by heat. Five blood flows out of 6, the first one being determined a month after the injury, showed a definite increase on the injured side (Case 10, Table I). Two oscillometric recordings were made at a 3 day interval. The first indicated a marked increase in oscillations, the second showed no difference between the 2 sides at the wrist and lower arm. Histamine flares were equal. X-ray films indicated an early spotty atrophy of the carpal bones. Within another month the pain and edema disappeared and the function of the arm returned three months following the injury.

In this patient no spreading neuralgia developed and regression of symptoms started within the first few weeks after injury.

*Intermediate case in state of regression complicated by compensation neurosis*

F H, a Mexican railroad laborer, suffered a fracture of the tarsal bones of the left foot. A cast was applied but a venous thrombosis of the deep veins of the lower leg necessitated the removal of the cast. He had severe burning pain in the leg and foot from the first few days on. He was immobilized off and on and received a great deal of physical therapy. His pain continued and the leg swelled each time he started to work. His lawyer started suit against the railroad. On examination, 1½ years after the injury, the left leg was moderately edematous and weight bearing was painful. The patient spoke poor English but his anxiety to obtain the maximum benefit out of his disability was obvious. X-ray films showed a mild osteoporosis in a stage of recalcification with coarse trabeculation (Fig 3). The peak of the osteoporosis had obviously been passed. It was felt that by obtaining a settlement and with the use of a nonpadded plaster cast his symptoms would be ameliorated. Six months after being seen he was working on another job, well satisfied, with a moderate painless edema.

*Early severe case treated by sympathectomy*

G D, a 39 year old colored woman, fell down two steps and sprained her ankle. X-ray films indicated no fracture. She was placed in a splint for 3 weeks during which time she had severe pain which would awaken her at night or come on during complete rest. Repeated X-ray examination revealed osteoporosis and again no fracture was found (Fig 18). In spite of heat, massage, and soaks, she continued to have pain for 2 months, after which she was ad-



Fig 18 Case of M O with good history of Sudeck's atrophy 8 months after injury. The normal foot is on the right.

mitted for study. The left ankle was markedly swollen, pain was diffuse, but most of the tenderness occurred on pressure below the external malleolus in the region of the lateral plantar nerve. This ankle was from 2 to 2.5 centigrades warmer than the opposite ankle. The oscillometric curve was higher on this side than the other. Four blood flow determinations indicated a marked increase of the affected side, a 28 per cent increase on the average (Case 12, Table I). Histamine flares placed on symmetrical areas of the dorsa of both feet revealed a much larger wheal and flare on the affected side. Following a lumbar sympathectomy the pain was completely relieved. The blood flow decreased. A shortening of the Achilles tendon was corrected by casts. The patient now works all day as a laundress.

*Late intractable case (Case 5, Table III)*

M B, a 46 year old woman, fell over a rocking chair and twisted her ankle on getting up suddenly to answer the phone. She complained immediately of severe, continuous pain. At an emergency station a fracture of the fibula was diagnosed and a posterior molded splint was applied in an equinus position. Two weeks later another cast was applied in a somewhat better position. After 5 weeks in this cast, an adhesive strapping was applied to the ankle, she still had continuous pain and weight bearing was impossible. Because of the disproportion of the pain to the well healing fracture of the fibula the patient was suspected of malingering. A general anesthetic was applied and during the first stage moderate pressure was applied to the injured ankle. At the time she was first seen the foot was in marked equinus position, the skin was glossy and the ankle was swollen. There was an increased growth of hair on this area and the nails were ribbed. A four plus Wassermann reaction was obtained (Fig 19a). Twelve blood flow determinations on each of the



Fig. 9. A Left, Photograph of M. B. 8 months after injury. The foot is discolored, swollen and in equinus position. B The roentgenogram reveals diffuse bone atrophy.

extremities revealed very low basal readings ( $-1.5$  c.c. of blood per 100 grams of tissue) with only slight increase of flow on the affected side. The volume of the injured limb was increased over that of its fellow. The affected extremity reacted very sluggishly to both a cold and hot water bath, the blood flow changing only very slightly.

X-ray films dating from 8 months after the injury revealed only mild osteoporosis of the ankle and a marked localized rarefaction in the lower part of the fibula. The bone later became diffusely osteoporotic and took on ground glass appearance which persists 1 year after the injury (Fig. 9b). She refused all therapy and has remained incapacitated to date. It is noteworthy that both hips and also her spine show moderate osteoporosis. Whether the local atrophy accelerated the appearance of a senile osteoporosis is, of course, impossible to tell.

The type I injury, the fault and insufficient immobilization, the mental attitude of the patient and the sympathetic attitude of her attendant all contributed to the outcome of this injury.

#### ANALYSIS OF STUDY

Many interesting and unsolved problems arise from the study of these reflex vasomotor disturbances. We shall discuss some of these in future publications. At present we shall comment only on such findings as may contribute to a better understanding and an earlier treatment of Sudeck's atrophy.

In the first place an early recognition of this syndrome seems important. In its milder forms, it is far from being rare. When a sprain or a blunt minor injury does not show a normal course of events but is characterized by excessive pain, vasomotor phenomena and increased pulsations of peripheral vessels, an

early reflex dystrophy should be suspected. As pain is purely a subjective phenomenon, the best diagnostic criterion is that of increased blood flow to the affected area. This can be substantiated by oscillometric curves, histamine flares and skin temperature readings, as plethysmographic studies are obviously not a reliable for clinical examinations. The truly functional hysterical manifestations following trauma, which one of us (G. de T.) has had the opportunity to examine in 2 instances, are not associated with such vasomotor phenomena. It must be stressed, however, that the differentiation of an early Sudeck's atrophy from traumatic hysteria is often difficult, as the emotional status of many of these patients is often unstable. This we have discussed in an earlier communication. Of our present series Case 18 (F. H.) has been repeatedly committed to an institution because of a severe psychoneurosis. Cases 27 and 28 seen quite early exhibited other instances of autonomic instability such as hypermotility of the intestinal tract and neurocirculatory asthenia. However the nervousness and excitability of the late cases may just as well be the result of many months of suffering and not the cause of the syndrome which most neurologists still maintain.

The osteoporosis which some authors have placed in the foreground of their discussion is not as typical for this syndrome as one might suspect. It does not appear early in fact nor

until 15 to 20 per cent calcium is lost from the bone. When it appears in its spotty form in the small bones of the hand and foot or in the lower metaphysis of the bones of the lower arm and leg, four to six weeks after the injury, it is rather characteristic. A diagnosis then, can be made but only in conjunction with the clinical phenomena. In the later stages, when the bone atrophy is diffuse, a roentgenological differentiation from other forms of atrophy hardly seems possible (fig 18). Besides, undoubtedly an atrophy of disuse has been superimposed on the atrophy due to increased blood flow. These extremities are splinted by the physician or by the patient himself, they are not in use because of pain on motion or on weight bearing. For every case of late Sudeck's atrophy showing diffuse osteoporosis one can show many cases of severe bone atrophy after immobilization which are painless and do not show the characteristic features of this syndrome. We have already commented on the fact that minor, partial nerve injuries of peripheral nerves coursing superficially between the skin and bone may sometimes be detected as the initial stimulus for the vasomotor phenomena. Thus the dorsal interosseous nerve in Colles' fracture, the superficial radial and ulnar branches in twists and torsions of the wrist, the superficial peroneal and the posterior tibial and saphenous nerves in injuries to the ankle are often stretched, contused, or surrounded by a perineural hematoma. The diagnosis of such partial nerve injuries would probably be made more often if examination would be directed toward them in cases of severe pain following trauma.

There are still a large number of cases, however, in which such injuries are not demonstrable and in which the irritative nerve lesion must arise in the numerous receptors of the tendons or ligaments. The periarticular structures of small joints in the fingers are especially endowed with sensory end-organs. But if the continuous irritation of these can give rise to vasomotor phenomena, to trophic changes, to bone atrophy, why would not rheumatic polyarthritis bring about such changes. And truly, when one examines the cold, clammy hand of such a patient, with

spindle shaped swelling around the small joints, with the marked atrophy of skin, contracture of tendons and joints with osteoporosis, the analogy between such a picture and a late stage of Sudeck's atrophy is striking. Another condition in which reflex vasomotor phenomena occur from a localizable nervous structure is the vascular syndrome caused by glomus tumors. The nonrecognition of a small subungual glomus tumor had led us to the diagnosis of Sudeck's atrophy following injury.

This was the case of I. C., a 60 year old machinist, who came to the Research and Educational Hospital on January 21, 1937, through the courtesy of Dr. Sumner L. Koch.

This patient complained of continuous severe pain in the right middle finger of 5 years' duration. In 1919 he had cut the tip of this finger which became infected. The scar became painful 10 years later and a spreading neuralgia developed first as far as the elbow, later ascending to shoulder and anterior chest wall. Squeezing the finger helped the pain. He kept a bucket of cold water next to his bed at night and plunged his hand in it for relief. The right hand was warmer than the left and there was a small linear, longitudinal scar at the tip of the right middle finger. The patient did not complain of any unusual sensitivity of the scar. Oscillometer readings showed a marked increase in oscillations on the affected side (fig 20).

A diagnosis of reflex traumatic vasodilatation was made. X ray films revealed no osteoporosis. On March 23, 1937, an anterior cervicodorsal sympathectomy was done, resulting in complete dryness of the extremity and a Horner's syndrome. There was marked relief from the burning pain in the hand and the spreading neuralgia within 24 hours. However it became apparent that the scar acted as a trigger zone and pressure upon it would elicit paroxysmal pain. Therefore, a week after the sympathectomy the scar was excised. A grayish nodule was observed within the fibrous scar, which was thought to be a neuroma. Histological examination, however, revealed it to be a glomus tumor. All symptoms disappeared.

Obviously the scar should have been excised before the sympathectomy, had one thought of a glomus tumor. In our experience, however, the removal of a neuroma in a scar or stump hardly ever gives lasting relief unless done quite early and usually aggravates the symptoms.

This case illustrates that a glomus tumor may become the origin of a chronic reflex

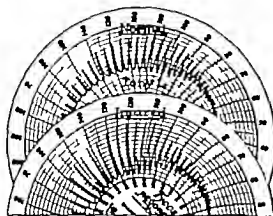


Fig. 30. Oscillographic curves of the normal and injured side. The individual pulse waves are higher on the injured side, but, in addition, the entire curve has shifted to the left. The displacement of spikes at 60 millimeters of mercury on the injured side and at 90 millimeters of mercury on the normal side indicates that the patient has vasodilation with increased peripheral resistance.

vasodilatation. This has been observed and commented on by Stahln, Thornton and Scott and is obviously another example of a vasodilator reflex in the extremities.

Blood gas studies performed by Dr F. A. Hick 2 weeks after both operations revealed that venous blood from the affected arm had a 64.4 per cent saturation of oxygen, whereas, the venous oxygen saturation from the other arm was 58 per cent.

It is our contention that, when carefully examined, the early case of posttraumatic dystrophy will frequently reveal a source of continuous nerve stimuli which are then responsible for the sensory and vasomotor phenomena. If such patients injured parts are adequately immobilized and rendered painless either by local infiltration of procaine or by sedatives and narcotics, the various short and long reflexes may not become established. It is a curious fact that severe fractures, which are promptly reduced and immobilized by closed or open reduction never and we say this advisedly give rise to Sudeck's atrophy. It is the minor injuries, whose immobilization is seldom carried out very carefully that are apt to be followed by this syndrome. The best prevention for Sudeck's atrophy seems the early and complete fixation of all injuries, without interfer-

ing with motion and permitting weight bearing as Roehler recommended.

A paradoxical finding should finally be discussed. If vasodilatation, increased arterial pulsation increased oscillographic readings, and increased blood flow can be demonstrated, especially in the early stages of Sudeck's atrophy why should sympathetic block or sympathectomy be of help and bring about such relief as we have reported. There are several possible explanations which need to be examined.

First, it is possible that the painful stimuli which give rise to vasodilatation, travel centripetally through the sympathetic fibers and ganglia. With the exception of Foerster and Leriche all experimental and clinical investigators deny that any impulses from the extremities are carried by the sympathetic nervous system. It is true however that a sympathetic block promptly abolishes the causalgia, burning pain of this syndrome without abolishing the vasodilatation. On the contrary it increases it.

This finding leads to another statement. The pain then is not due to vasodilatation at least not the kind that block of sympathetic fibers produces the pain causes vasodilatation.

The second possibility is that the reflex vasodilatation of Sudeck's atrophy is mediated by efferent vasodilators in the sympathetic nervous system. We have discussed the evidence that they do exist in man. However if such a mechanism were operating the pain would be unrelieved and vasodilatation abolished after sympathetic block whereas, exactly the opposite is true.

The third possibility is that the vasodilator efferent fibers of the posterior root system, which are stimulated either directly or reflexly by the trauma, secrete a pain substance which is diffusible and would explain the peculiar types of hyperesthesia which are observed in Sudeck's atrophy. These fibers correspond to the "nociceptor system" of Sir Thomas Lewis. Sympathectomy then would not interfere with this nervous pathway but by accelerating circulation would eliminate or wash out the pain substance. This same mechanism would explain the fact that a herpes, seen in a causalgic hand rapidly

healed after sympathectomy (15) and that shingles, which are certainly due to an irritation of the posterior root system, are rendered painless and made to heal after paravertebral block (our observations)

A final possibility should be mentioned. If the vasomotor disturbance in Sudeck's atrophy is such that an arteriolar dilatation exists together with capillary spasm (Fig 20), then the pulse waves reaching the capillary bed may stimulate the sensory receptors and produce a throbbing pain with each pulse. Sympathectomy in such a case would release the venocapillary obstruction, and while blood flow would be further increased, it would not cause pain. There are certain observations to show that such a condition may exist in some patients. Thus, in a number of instances, the affected extremity is cold, clammy, sweaty, and shows the earmarks of sympathetic hyperactivity, it also feels cold to the patient, and yet the blood flow is increased. This is the case in hands of patients suffering from rheumatoid arthritis.

We have no data at present which would enable us to choose between the last two explanations. It may even be that both mechanisms may operate simultaneously or in successive stages. The hot, red extremity of a polyneuritis is sometimes followed by a cold, cyanotic stage and yet blood flow is still demonstrably increased. These problems await further investigation.

Whatever the explanation is, repeated sympathetic block in the earlier stages and sympathectomy in the later, more intractable cases have been of decided benefit. The procaine infiltrations can be followed by mild physical therapy which, if used alone, often aggravates the pain and muscle spasm. When organic changes are present, such as shortening of tendons, shrinking of joint capsules, ankylosis, and faulty position, they need orthopedic care for a full functional recovery after sympathectomy.

#### SUMMARY

Attention has been called to a not infrequent posttraumatic syndrome described by Sudeck in 1900. The diagnosis can be made by the early appearance of severe continuous pain, at first localized to the site of injury,

later spreading proximally toward the root of the limb and sometimes even to the trunk and the contralateral extremity. The injury is usually comparatively mild and involves nerve trunks, blood vessels, or periarticular structures. Satisfactory immobilization, infiltration of the site of injury with procaine, or repeated paravertebral block with procaine may abort the progress of the disease. Next to the spreading neuralgia an increased blood flow to the affected extremity is demonstrable with the oscillogram, with histamine flares but more accurately with a water plethysmograph. Over 100 blood flow determinations have been made on 12 patients. A total of 33 patients suffering from early, intermediate, and late stages of the disease have been reported. The roentgen findings of a spotty, later diffuse, osteoporosis are helpful in corroborating the diagnosis but are not essential for the diagnosis. The treatment must fit the duration and severity of the syndrome and consists of repeated injections of procaine into the injured area, paravertebral sympathetic block, periarthral sympathectomy, and sympathetic ganglionectomy. Orthopedic correction may be needed for the late cases after the pain has been stopped.

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# IMPROVED METHOD OF MEASURING THE POTENTIAL DIFFERENCE ACROSS THE HUMAN GASTRIC MEMBRANES AND ITS CLINICAL SIGNIFICANCE

## A Preliminary Report

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IN 1936 Adair and Goodman reported a method of measuring the potential difference across the stomach membranes in an effort to quantitate the state of vagotonia often observed in cases of peptic ulcer. In 1937, in collaboration with J. P. Quigley and Sir Joseph Barcroft, certain factors modifying the potential were elaborated. It was concluded that the gastric potential is not dependent on the hydrogen-ion concentration of gastric contents nor upon the well known types of gastric activity—that is, the secretion of acid, mucin, or pepsin—nor upon hunger contractions, digestive contractions, or other types of motor activity, nor upon the diffusion of ions or nonelectrolytes. The potential difference within the lumen of the stomach or of a gastric Pavlov pouch is negative with respect to the abraded skin and during fasting periods the potential difference is relatively constant. The potentials of the cardia and pylorus differ about 5 millivolts in magnitude but generally change in the same direction. The potential difference is lowered by contact of milk, emulsified fats, alcohol, or dextrose with the gastric surface, but in the case of the latter two not by their introduction in the blood stream. It was felt that this gastric potential difference depends on an undetermined type of activity, apparently of the gastric mucosa, and that when altered by contact of the mucosa with effective substances, the influence may be transmitted to gastric tissue not in contact with the excitant.

In 1939 the method was modified and applied to humans. Through the suggestions

and collaboration of Dr. Kenneth Cole of the department of physiology of the College of Physicians and Surgeons of Columbia University the type of electrodes was changed. We employ liquid junctions which are easily renewable by washing and the electrodes do not make direct contact with living tissue. The potential differences are balanced by a recording potentiometer. These potentials are then independent of resistance changes and electrode polarization effects in the system measured.

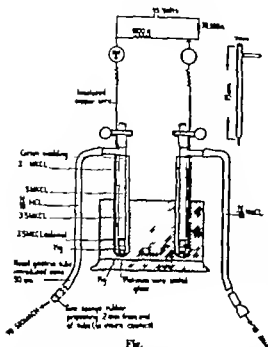
Figure 1 illustrates the construction of the electrodes. The insulated copper wires are attached to a Leeds and Northrup special micromax recorder. The external resistance of the circuit is in the range of 50,000 to 100,000 ohms. The recorder has a range of 0 to 100 millivolts with an accuracy of 1 per cent with an external circuit resistance of 50,000 ohms and an accuracy of 1 to 2 per cent with an external circuit resistance between 75,000 and 100,000 ohms. There is also a special shunt whereby the electrodes may be calibrated against each other. The recorder is set to run at 1.4 centimeters in 5 minutes.

Figure 2 shows the calibration of one electrode against another. This is done by placing the side arm tubes of the electrodes in normal saline and 1/10 normal hydrochloric acid, and running the machine at a known resistance recorded on the shunt. This shows that there is practically no difference between the two electrodes as the shunt resistance and recorded voltage is essentially the same.

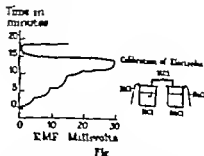
Figure 3 shows the actual setup on a patient. The electrodes are prepared for use and applied to the patient in the following manner.

The I tube pyrex glass tubing in one end of which is sealed a piece of platinum, is thor-

From the Department of Surgery, Columbia University and the U. S. Naval Service, The Veteran Hospital, New York.  
Aided by a grant from the Commonwealth Fund.



oroughly cleansed and dried. It is then filled as shown with a small quantity of clean dry mercury to cover the protruding platinum wire and layered on this is a small quantity of calomel mixed with 3.5 molar potassium chloride. The tube to the T joint is then filled with 3.5 molar potassium chloride and 3 pieces of cotton wadding are introduced at convenient distances. This prevents dispersion of the electrolytes and after the electrodes have been used some 3 to 4 times, the upper 2 cottons are removed and fresh 3.5 molar potassium chloride introduced. Some 20 minutes before use on the patient the electrodes are further prepared by attaching the side arm of one to a rubber tube to be used for the arm lead and filling this with 1/10 normal sodium chloride solution by aspiration with an aseptic syringe. The fluid remains in the tube since one end is clamped. The other electrode is similarly prepared. However the nasal gastric tube is more easily filled by injecting the 1/10 normal hydrochloric acid solution into the nasal gastric tube. After both have been filled the apparatus is allowed to stand 30 minutes before use.



The test is performed on a fasting patient with an empty stomach. If there is reason to believe that there is gastric retention the stomach must be lavaged clean before the test is performed. Supper is allowed the evening previously but no further food or liquid other than water until the following morning when the test is usually run between 7:30 and 8:00 a.m. The routine employed has been:

1. Nasal application of a 2 per cent cocaine in spray is made.

2. The right forearm ventral surface is slightly abraded with a needle and a rubber cuff containing a glass cup is applied over the abraded area, and the cup is filled with 1/10 normal sodium chloride solution. The filled nasal gastric tube attached to the side arm of the electrode is then introduced through the nose into the stomach, some 50 to 56 centimeters. The arm lead is then attached to the glass cup and the record is started.

3. An immediate response is recorded and this is allowed to progress until either a steady baseline is obtained or until it is apparent that the response is assuming a definite pattern. This usually requires some 10 to 15 minutes. When the latter occurs, the patient drinks 50 to 200 cubic centimeters of milk and the change in potential is noted for another 10 to 15 minutes.

Eight to 10 runs are performed on a set of electrodes.

#### EXPERIMENTAL DATA

The following is a preliminary report of data concerning the different electrical potential responses evoked by milk in the various gastrointestinal lesions. In the preceding experimental work, it was shown that milk

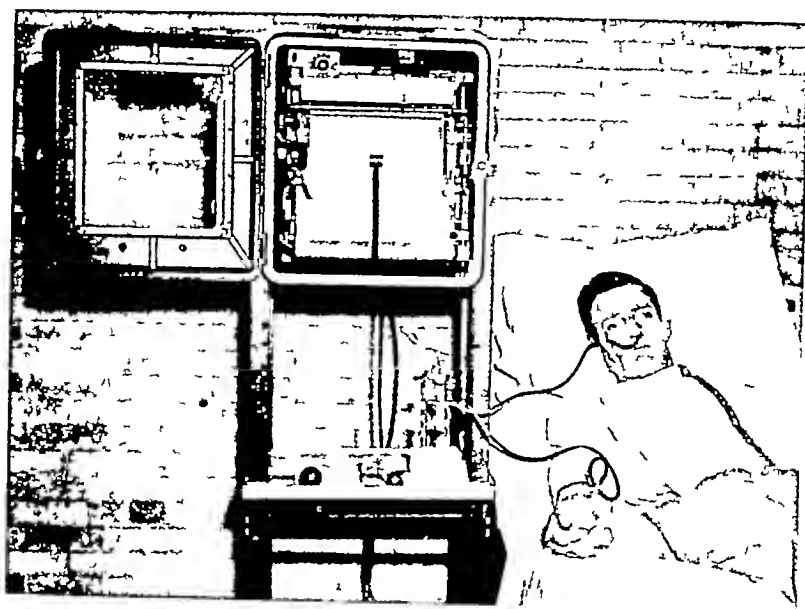


Fig 3

altered the potential in a fairly uniform pattern in the dog and sheep. By the use of the response to milk in humans, it was soon apparent that so called normal humans likewise had a potential difference of a fairly constant character and magnitude. With this phenomenon the stomach is being studied in various diseased conditions to ascertain whether it reacts in different and characteristic fashions. The following data are the empirical correlations of the standard test response to milk with known disease found at operation or through clinical course.

Before proceeding with the various lesions, certain data are pertinent showing that (1) the milk response occurs only when there is contact with gastric mucosa and will not take place *in vitro*, (2) the response to milk seems to be specific for the stomach.

The potential difference between the contents of the two beakers is noted. Milk is added to the beaker containing gastric juice. No change in the potential difference occurs (Fig 4).

Mr L, a patient suffering from cardiospasm some 40 years, 4 years ago required a gastrostomy for feeding purposes. With the gastric tube placed in the stomach through the gastrostomy opening milk in the esophagus taken by mouth fails to alter the potential difference in the stomach. However, immediately the patient forces milk through the

esophagus into the stomach, a response occurs (Fig 5).

Mrs H had a total gastrectomy some 3 weeks before the curve illustrated in Figure 6 was made. With the nasal tube through the anastomosis in the jejunum, milk fails to evoke a response.

The next three graphs are introduced to show that the bizarre patterns sometimes obtained in the gastric lesions are not necessarily artefacts due to changes in the electrodes.

Figure 7 shows a potential difference response in a normal subject, performed on March 4, 1941. Figure 8 shows the potential difference response of a patient having intermittent gastric dilatation and hemorrhage due to malnutrition and cachexia. Figure 9 shows the potential difference response of the same patient as in Figure 7, but on March 7, 1941 using the same electrode as in Figure 8 and thereby demonstrating that the bizarre response in Figure 8 is not due to electrode phenomenon.

Figures 10, 11, 12, 13 are representative curves in a series of cases of the various lesions to be presented. These were compiled from the first 150 cases done with the present setup.

The following is the elaboration of characteristics of response in the various groups of lesions.

*No known disease* (Fig 10) The characteristics of 24 of 25 cases may be summarized as having (a) a steady baseline, (b) an immediate response to milk, (c) a smooth curve

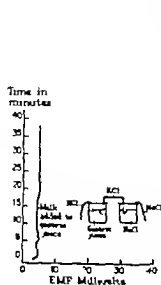


Fig. 4

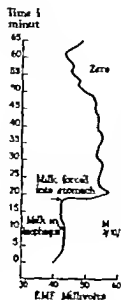


Fig. 5

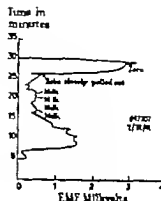


Fig. 6

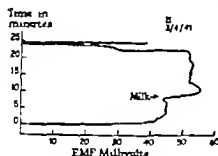


Fig. 7

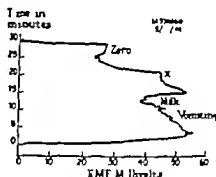


Fig. 8.

as a response (d) a range of between 40 and 60 millivolts (e) a highest rise of 11 millivolts and the lowest of  $3\frac{1}{2}$  millivolts, (f) a sustained rise averaging 5 minutes, the shortest 4 minutes, the longest 15 minutes

One subject whose curve is not shown presented an irregular baseline and an irregular sustained rise after an immediate response to milk. This subject was an interne at the time under considerable distress and was later shown to have considerable pylorospasm

*No intrinsic disease of the stomach—known disease elsewhere* These 10 cases represented carcinoma of the cecum adenofibroma of the breast carcinoma of the head of the pancreas,

carcinoma of the sigmoid and a ventral hernia, also retroperitoneal sarcoma, metastasis to spine—primary carcinoma site unknown, gall bladder disease etc.

All of this group showed (a) an immediate response to milk (b) a steady baseline (c) a smooth curve response (d) a range of between 35 and 60 millivolts, (e) a highest rise of 14 millivolts and lowest rise of 3 millivolts (f) a sustained rise averaging 5 minutes, the lowest being 3 2 minutes. The characteristics of this group are similar to the normals.

*Duodenal ulcer* (Fig. 11) The verification of diagnosis in this group of 25 cases was confirmed either by repeated x ray examination

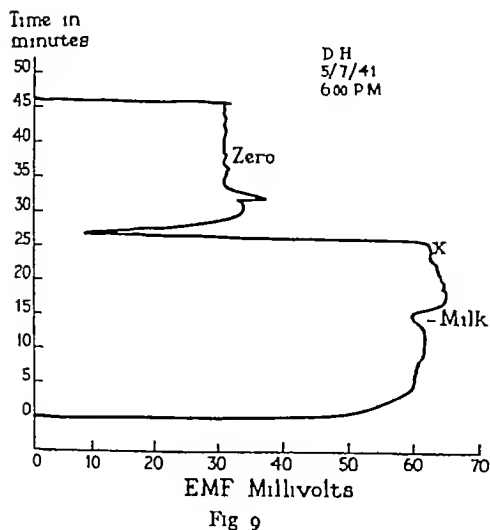


Fig 9

or by pathological examination after operation. They include 3 patients who had had a previous gastroenterostomy who were found to have duodenal and jejunal ulcers. One patient in the group in addition to having a duodenal ulcer was found to have unsuspected chronic myeloid leucemia. The tests were made before operation.

The characteristics of this series are (1) a steady baseline when there is no associated gastric pathology, (2) an immediate response to milk, (3) a smooth curve, (4) a highest response of 11 millivolts, lowest of  $2\frac{1}{4}$  millivolts, (5) a shortest sustained rise of 5 minutes and longest of 10 minutes, (6) a voltage ranging between 35 millivolts and 60 millivolts. These characteristics were noted in all of the 25 cases.

**Gastric ulcer (Fig 12)** The diagnosis in this group of 30 cases was confirmed either by operation or repeated gastrointestinal series with follow-up. Twenty patients were operated upon, partial gastrectomy being done. The 10 remaining patients had repeated gastrointestinal x-ray films and have been followed for an average of 7 months. The tests were made before operation.

An illustrative case is presented.

A man aged 56 years had a 6 months' history of insidious anorexia and acute history of 12 hours of vomiting (Fig 14). Two gastrointestinal series by our senior roentgenologist were interpreted as car-

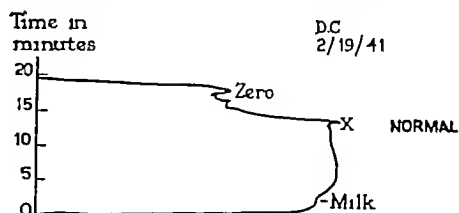


Fig 10

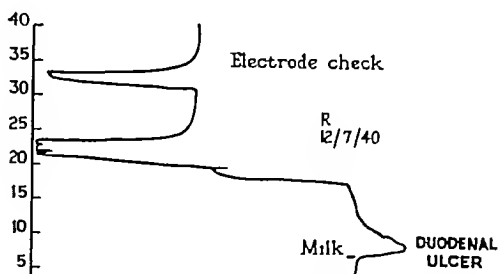


Fig 11

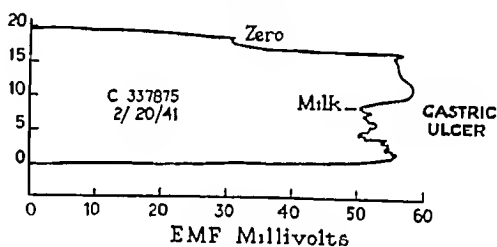


Fig 12

cino of the prepyloric region. The patient had an average free hydrochloric acid. At operation there was found a sharply defined, hard lesion involving the pylorus and prepyloric region with a white zone on the corresponding serosa. There was one enlarged lymph node. However, microscopic section revealed a gastric ulcer with hypertrophy of the pyloric muscle and no carcinoma. A follow-up of 6 months shows the patient in excellent condition.

The characteristics of this group are (1) the baseline tends to be irregular with the interposition of short, fast deflections of the galvanometer, (2) there is an immediate response to milk, (3) the curve may not be a smooth curve, the same short deflections being interposed on the curve. The response to milk is greater in millivolts than any of the irregularities of the baseline. The highest response was  $13\frac{1}{2}$  millivolts and the lowest  $2\frac{1}{4}$  millivolts, (4) the average rise was 5 minutes and the longest, 15 minutes. This group differs from

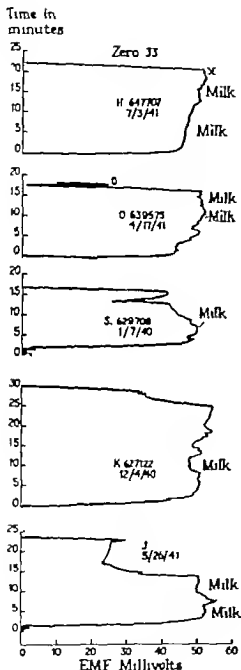


FIG. 3

the duodenal ulcer group and from the normal by the interposition of the short fast deflections. In this group of 30 cases 26 of the 30

exhibited the characteristics of response elaborated. Of the 4 cases which showed different characteristics 1 had a rise in potential similar to the above but the baseline had been falling previous to the introduction of milk and the response in potential difference was not higher than the highest point on the baseline although the type of response fell into the same characteristics as the general group. This case showed duodenal and gastric ulcers with papillomatous proliferation of Brunner's glands projecting into the pylorus and with polypoid hyperplastic lymphoid gastritis of the antrum. Two cases showed a bizarre irregular baseline with a bizarre irregular response to milk. One was a case of recent gastric perforation with a prepyloric mass which required a secondary gastroenterostomy for obstruction. The lesion was thought to be an ulcer because of the favorable follow-up of some 3 months. The other case presented an unusual picture of multiple shallow ulcers surrounded by inflammatory cells, the ulcers being mainly in the mucosa and submucosa of the proximal half of the stomach with a suspicious bowl-shaped ulcers with sloping margins in the distal half of the stomach. The fourth case was a man with a gastric ulcer which grossly was suspicious of cancer but turned out to be nonmalignant on section. This man had 2 curves, one of which was characteristic of the response noted above, the other of which however failed to give a response to milk though the baseline was falling before milk was given.

This group of 30 cases is of interest because from a clinical, roentgenological and gastroscopic opinion the diagnosis was most difficult. The x-ray findings in this group are summarized by Dr. Paul Swenson of the department of roentgenology. This group of 30 cases is traced over 3 gastrointestinal x-ray examinations.

Six were diagnosed as duodenal ulcers, 8 as benign gastric ulcers, 9 as suspicious of cancer and 7 were definitely diagnosed as cancer. Dr. Swenson states:

This series that we have studied includes 30 cases of peptic ulcer in which the differentiation between ulcer and cancer was not certain. In all but a few the question of neoplasia

had been raised at some time during the series of examinations. There were certain roentgen criteria which made the examination favor one more than the other. There were 8 cases considered benign because the character of the crater shadow and its definite reaction to dietary regimen. However, in 16 cases the radiologist or the several roentgenologists felt that the differentiation between ulcer and cancer simply could not be made from the x-ray findings alone. The findings upon which this suspicion of neoplasm was based were (1) the failure of the crater to decrease in size upon therapy, (2) the lack of symptoms, (3) a relatively large area of inflexibility around the ulcer crater suggesting either malignant infiltration of the wall or a large area of inflammatory induration, the two being indistinguishable.

"On the side of benignity the suggestive roentgen evidence was (1) the definite diminution in size of the crater under therapy (not wholly a reliable sign), (2) the intermittent relaxation of areas of constriction which proves that these were areas of spasm rather than infiltration, (3) the peristaltic activity within the area of supposed involvement.

"The amount of retention in the stomach had little to offer either way as far as the differentiation of carcinoma from ulcer was concerned. It is of interest that the examiner definitely favored neoplasm in a fairly large number of cases. The percentage of these cases in which neoplasm was definitely favored would, I believe, be about the same as that in a similar series in a carcinoma group in which the same criteria come into use. In other words, there is a certain group in which the radiologists simply cannot be certain without a number of examinations during therapy to watch for any change."

The gastroscopists have been consulted in 6 of these 30 cases, 3 were diagnosed as cancer. Therefore the gastroscopist is unable to be more specific than the radiologist.

*Other gastric diseases* (Fig 15) This miscellaneous group of 10 cases is included although there is an insufficient number to indicate that these conditions show a different response from the cancer group. These cases include hypertrophic gastritis, atrophic gastritis with

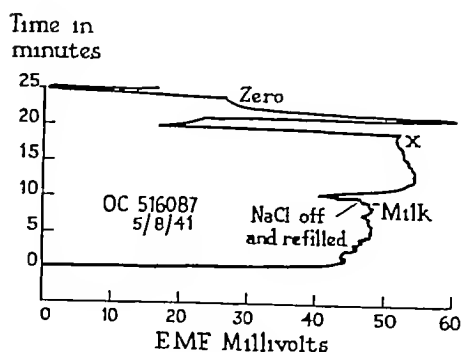


Fig 14

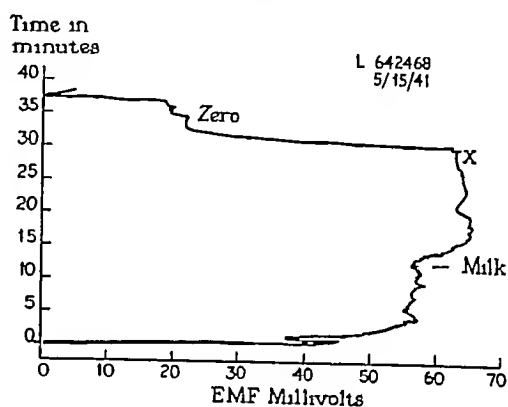


Fig 15

achlorhydria, duodenitis with herniation of gastric mucosa into antrum, pylorospasm with duodenal ulcer and associated gastritis, and cases of gastric symptoms but with entirely negative laboratory findings. A case of gastritis is shown in Figure 15. This series revealed a tendency toward an unsteady baseline and immediate response to milk, the curve of which tended to have the interposition of short, irregular deflections, a range between 40 to 60 millivolts, the shortest sustained rise 5 minutes and the longest 30 minutes, the rise in all cases averaging 5 to 16 millivolts. This group all exhibited the characteristics of the gastric ulcer pattern in which it is noteworthy that short, rapid deflections occur.

*Carcinoma* This group of 46 cases, though hardly presenting a sufficient number of cases, is worthy of a preliminary report in that it appears that the response to milk in the electric potential difference in cases of carcinoma is different from the response of other lesions



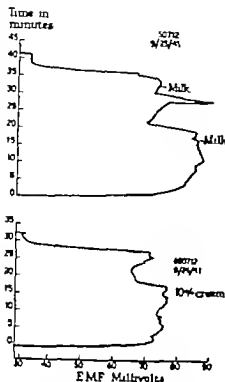


Fig. 16. Before operation.

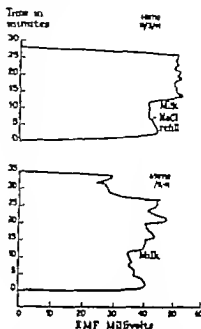


Fig. 17. After operation.

Two further cases are given in detail to indicate the probable usefulness of this method

A 56 year old porter (Figs. 6 and 7) had epigastric pain, vomiting, and weight loss over a year period but much worse for 3 weeks before admission. He had a known duodenal ulcer history of 5 years standing with symptoms of intermittent hemorrhage and pain. On admission, the gastrointestinal series revealed no per cent gastric retention and only slight free hydrochloric acid. There was not great deal of improvement on lavage, and gastroenterostomy under local anesthesia was performed, revealing crooked, scarred area in the pyloric region. This did not have the gross appearance of cancer. However the patient failed to improve after operation, at which time the x-ray examination revealed obstruction of the gastroenterostomy of the inability to force barium through the pylorus. At this time the roentgenologist raised the question of malignant neoplasm of the antrum. The patient was reoperated upon on September 5, 1941.

At this time there was described edema of the distal limb of the gastroenterostomy and the same pocketed, lacerous-looking scar in the antrum. A subtotal gastrectomy as performed with dissolution of the gastroenterostomy. Microscopic section revealed superficial spreading carcinoma in the region of the old gastric ulcer the tumor only one point penetrating to the adjacent muscularis. There were metastases in 3 inferior gastric lymph nodes. There was no real obstruction at the pylorus.

All of the cases but 1 have been verified at operation with microscopic sections.

Figure 13 shows 5 cases of cancer the responses of which may be characterized by a steady rise in the electric potential with the superimposition of short fast deflections and in which there is no marked response to milk. In the second group there is a general rise in the potential difference on which the same short fast deflections occur and there is no response to milk. In the third group there is a negative response to milk. The fourth group showed an irregular box like pattern of the baseline with the interposition of the short fast deflections and with the same pattern being repeated after the introduction of milk. A fifth type—there are 4 cases in this series—shows an irregular baseline of these same characteristics and after on introduction of milk an immediate spike-like rise and fall of the potential lasting about 2 minutes. All 4 of these cases have a very advanced malignancy with multiple gross metastases.

In this case it was felt reasonable to assume that the lesion of the stomach had been successfully extirpated. The potential difference response before and after operation is shown, indicating an entirely different response post-operatively.

A second case (Fig 18) is given of a 47 year old colored woman who in 1924 had a cholecystectomy. For 2 years previous to admission she complained of abdominal pain, nausea, anorexia, and weight loss. Six months before admission these symptoms became worse. X-ray examination revealed an obstruction near the pylorus with tenderness in this region and the antrum failed to contract in systole. The patient had a normal free hydrochloric acid. At operation a subtotal gastrectomy was performed for a stenotic ulcer at the pyloric junction penetrating along the posterior wall on to the pancreas. Grossly this had none of the characteristics of cancer. However, microscopic section revealed a poorly differentiated and diffusely infiltrating carcinoma developing on the base of an old ulcer with metastases to 4 lesser curve lymph nodes. The resection seemed to have been through tumor tissue. The electric potential difference response before and after operation is shown and the curves seem to be identical in characteristics.

In this series of 46 cases there were 5 cases which differed in characteristics from the others. One, a man with a very advanced lesion presenting a mass in the abdomen and an enlarged liver, had an irregular baseline with a sharp response to milk. There were 2 patients who on different preoperative tests revealed curves, which at one time were characteristic of the cancer group and at another time of the ulcer group. The fourth case was a man with an advanced lesion in which there was a response though this response was not as high as the former baseline. The fifth case was a young man with extensive lesion penetrating through and invading the liver, in which there was an irregular baseline, a rise to milk with resumption of the same irregular baseline.

#### SUMMARY

A method is presented for measuring the potential difference across the human gastric membranes. This method is noteworthy in that the electrode system makes no direct contact with the skin or stomach.

A standard test was evolved using the potential difference response to milk as the

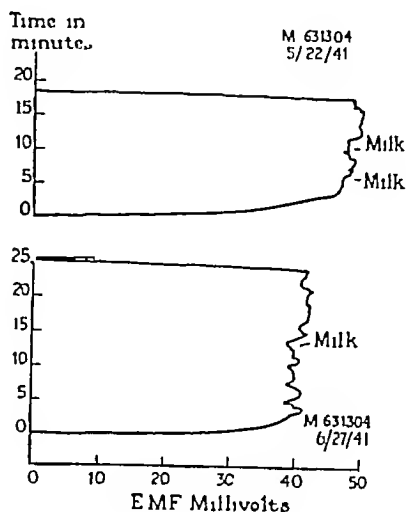


Fig 18 Above, Before operation, below, after

control measurement. Data are presented on the various lesions indicating a different response to milk in the corresponding lesions.

#### CONCLUSIONS

Though the gathered data are suggestive, there is not sufficient material for conclusive deductions.

More accurate diagnoses on these types of cases should be made using this method in conjunction with roentgenological interpretation and gastroscopy.

The method appears useful in differentiating gastric carcinoma from other gastric lesions and this phenomenon seems more consistent the earlier the gastric carcinoma, both from time of onset of symptoms and from the extent of spread. The short, fast deflections mentioned appear only in gastric lesions and the true form and characteristics of the short, fast deflections which may have characteristics for each group will have to be investigated with a more sensitive and faster recording apparatus. There are many phases of the problems under consideration and experimentation, notably (1) the responses obtained after gastrectomy, (2) the sources of the potential difference, (3) the different electrical properties of cells in correlation to different lesions, (4) the nature of the short, fast deflections.

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# CLOTHESPIN OR INCLUSION GRAFT FOR SPONDYLOLISTHESIS OR LAMINAL DEFECTS OF THE LUMBAR SPINE

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**B**ECAUSE of our dissatisfaction with the results of spinal grafts in spondylolisthesis and the difficulty of satisfactorily bridging laminal defects with grafts of previous types, we attempted to fasten tibial grafts in place with vitallium screws. This proved unsuccessful. The screws worked loose and contact could not be maintained. Absorption of massive portions of the grafts then took place. It occurred to us that if a graft could be devised which by its shape would be rigidly maintained in place in the lumbar spine without other method of fixation, better results in these two conditions could be secured. At first we designed an inclusion graft to place over the spinous processes of vertebrae which we desired to fuse. The patient was placed in a position of hyperextension before the graft was applied (Fig 1, a). Such a graft was used successfully in a case of spondylolisthesis in conjunction with chips of bone removed from the ilium and placed beneath the graft. Though this case progressed to an entirely satisfactory conclusion and solid ankylosis, the technical difficulty of making an inclusion graft, and its weakness when made, forced us to use a stronger substitute. We therefore devised the double clothespin graft (Fig 1, b). In this the intervening spinous processes were removed between the vertebrae to be ankylosed and the two ends of the graft so fashioned as to include the spinous processes of the end vertebrae of the fusion area. It was found at operation that besides strength another favorable factor was secured by the double clothespin graft. With the patient in a flexed position, so as to distract the spinous processes between which the graft was to be placed, a leverage action was secured by the abutment of the spinous processes on the ends of the graft when the patient was straightened out. There was actually distraction of the articular facets, open-

ing of the intervertebral foramina, and separation of the vertebral bodies (Fig 2). This gave theoretical reduction, at least, of any pressure on nerve roots passing out through the intervertebral foramina. Such actual distraction of the vertebral bodies included in the grafted area has been observed. Possibility of further displacement of spondylolisthesis by distraction has been watched for but not observed. On the other hand, replacement of spondylolisthesis by the distraction has likewise not been seen. Fixed continuity of transplanted bone with the grafted area has always been present.

We have used 1 inclusion graft, 16 double clothespin grafts, and 1 single clothespin graft. In the 18 operations done, there were 6 cases of mild shock, 2 of moderate shock, and in 1 patient death occurred 2 days after operation. The ages of the patients ranged between 18 and 55 years. Seven patients were women. All were of the white race, most of them Americans, and all walks of life were represented. The operation was performed for spondylolisthesis in 6 instances (Fig 3), 5 of them being of the 5th lumbar and the other, a posttraumatic fracture spondylolisthesis, of the 4th lumbar. In all there were 12 patients in whom a double clothespin graft was placed in association with the creation of laminal defects. In 11 patients the graft was used to reinforce a defect due to posterior herniation of the nucleus pulposus and accompanied partial or complete laminectomy (Fig 4). In 1 instance it was used to bridge a massive defect of several vertebrae necessitated by exploration and removal of a cord tumor in which articular facets were removed and stability of a long section of the lumbar spine lost. This exploration and laminectomy were performed by another surgeon, the graft being laid by us.

In 2 instances, laminectomy defect had been created at previous operations. All other lami-

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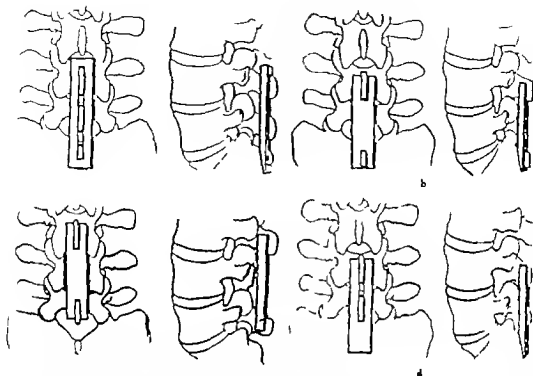


Fig. a, Inclusion type graft. b, Double clothespin graft set between spinous processes of 4th lumbar and 5th sacral. c, Double clothespin graft set between spinous processes of the 3d lumbar to 5th lumbar bridging lumbar.

easy defect of 4th lumbar. Note undercutting of spinous processes. d, Single clothespin graft as used from spinous processes in previous spine fusion below or to sacral surface which lacks spinous processes.

nal defects were created and accompanied at the same operation with grafts of this type.

The length of time of operation varied from 60 minutes in spondylolistheses to 2 hours or more in laminectomy cases, depending upon the necessity of search for or exposure and removal of any pathological condition present in the latter. Operative time was markedly reduced when two capable teams were associated, one in exposing the spine and the other in securing the tibial graft.

The clothespin grafts were reinforced with iliac chips on 11 occasions and with additional tibial bone on 3 occasions. In one instance the slot in the lower end of a graft was cut too narrow for the spinous process. As it was being driven on, one of the prongs broke off. Despite this good stability remained at operation. Subsequently the lower end displaced laterally but maintained contact with the spinous process and sacrum. Review of post-

operative x ray films showed that a possible fracture of the upper prong of another graft may have occurred, this without displacement of either the main graft fragment or the prong. No fracture of the main body of the graft has occurred in any of the cases to date. Immediate stability of all grafts, both inclusion and clothespin, was excellent. Final stability of all grafts has remained good to date. In 10 of the 18 cases, jacket cast was applied immediately after operation to prevent the possibility of the patient being drawn into the flexed position and of displacement of the graft. Since, however, in 8 patients no cast was applied after operation and there was no displacement of the grafts, it is believed by the author that a jacket cast is an unnecessary detail.

All wounds with the exception of 1 healed *per primam*. One other spinal wound broke down 3 weeks after suture removal. In both in-

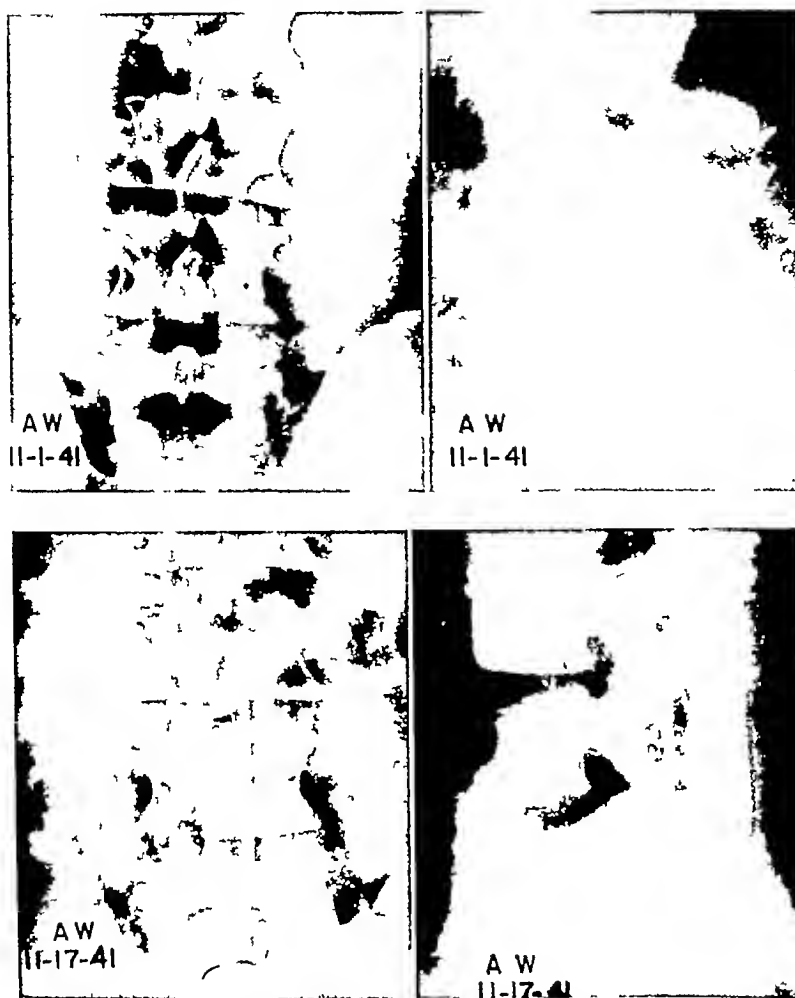


Fig 2 A W By contrasting the spaces of the intervertebral disc and the intervertebral foramina in the upper pictures with those below, it can be seen that actual distraction of the posterior and anterior elements has occurred

stances, a silk suture has been extruded, and in 1 healing has taken place. The probabilities are that other deep silk sutures will have to be removed from the unhealed wound. All tibial wounds healed *per primam*, but in 1 instance, in which sulfathiazol was used, the wound reopened 5 weeks after operation, drained a few days, and then healed. The average period before the patient became ambulatory has been 21 to 24 days after operation, though 1 patient became ambulatory after 9 days and 2 others after 18 days. The local condition of the site of removal of tibial

bone will control the return to weightbearing. Absorption of graft or spinous process due to pressure contact has not been observed in any instance.

The extent of the graft has been from the 3d lumbar to the 1st sacral, 8 times, the 4th lumbar to 1st sacral, 4 times, the 3d lumbar to 5th lumbar, twice, the 4th lumbar to 2d sacral, twice, and the 2d lumbar to 5th lumbar, once. One additional graft was placed across 5 vertebrae for defect caused by exploration and removal of spinal cord tumor by another surgeon.



Fig. 3. M. P. M. with arthrodesis of the 4th lumbar to 4th sacral for spondylolisthesis.

#### DESCRIPTION AND MINUTAE OF OPERATIVE PROCEDURE

The clothespin graft consists of an abutment of bone between two given spinous processes held in place by prolongations from either corner of the ends of the bony graft the latter giving the appearance of a clothespin (Fig. 5). In the inclusion graft, the reverse effect is secured with a loop of bone in the form of a graft enclosing the spinous processes. As we do not favor the use of the latter type of graft we shall not continue its description. In

a typical single or double clothespin graft, the posterior elements of the laminal arches are denuded and decorticated except for the spinous processes at either end of the area to be grafted. These are retained. Occasionally in a severe spondylolisthesis the posterior arch of the displaced vertebra will have been driven back so that it partially overrides the arch of the vertebra above and below. Such an arch may be removed to allow for the application of the straight clothespin graft without leaving much of a defect in the continuity of the

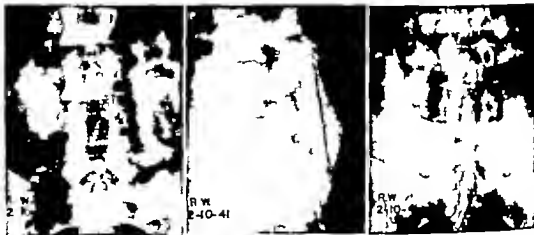


Fig. 4. R. W. Repair of old laminectomy defect in 4th lumbar by double clothespin graft from the 5th lumbar to the 5th lumbar.

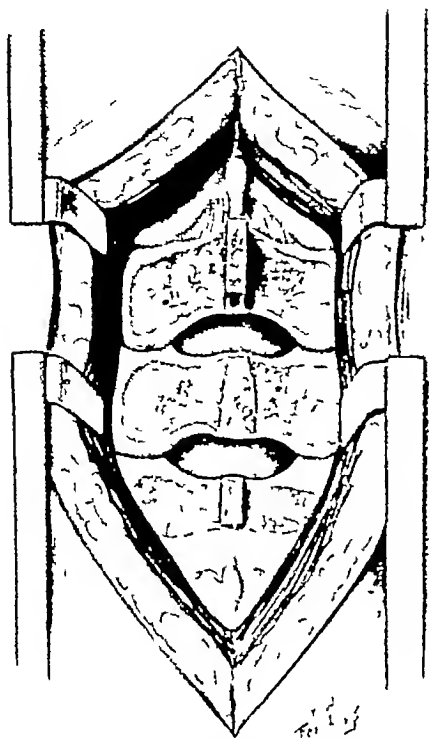
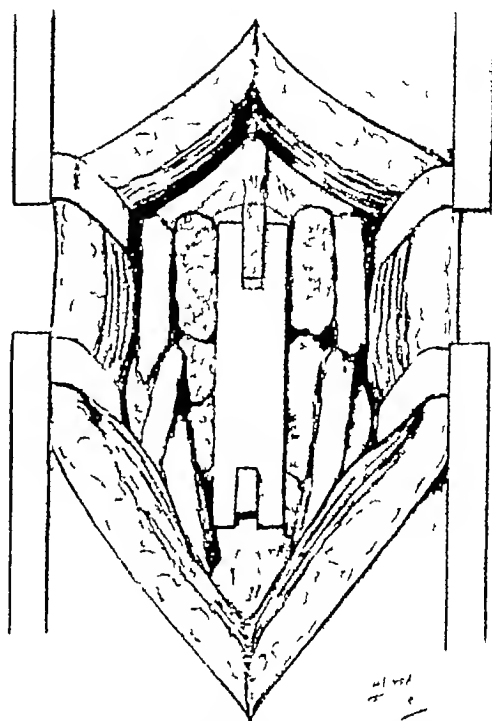


Fig 5 a, left, Shows the preparation of the posterior elements of spine with squaring off of spinous processes of the 4th lumbar and the 1st sacral and the removal of the



spinous process of the 5th lumbar b, The implantation of a double clothespin graft which is reinforced with iliac chips

laminal arches left behind. The patient should be placed upon a table in a flexed position, so as to spread the spinous processes apart. The spinous processes should be squared off on their lateral surfaces and on the margin which will be in contact with the graft. The opposing margins of the spinous processes between which the graft is to be laid should be slightly undercut. When the patient is in the extended position, the graft will then be forced to a deeper position rather than be extruded by pressure. After the spine preparation has been carried out, a malleable probe can be bent accurately to fit between the spinous processes which are to be included. A clothespin graft can be cut from the upper tibia, the abutting portion of the graft being cut accurately to the length of the previously bent probe or measure. The abutting or slotted ends of the clothespin graft should be cut at a slight bevel to match the undercut margins of

the spinous processes. This will aid in retention of the graft *in situ* when the patient is straightened out. When the graft extends below the 5th lumbar segment, the deep borders of the distal clothespin prongs will have to be beveled up sharply to match the dorsal curve of the sacrum. Occasionally, to secure a good strong base on the sacrum, it is necessary to by-pass the 1st sacral and anchor the graft to the 2d sacral spinous process. When previous fusions have been done, the upper border of the previous fusion may be undercut and notched transversely. The tibial graft is cut as a single clothespin above with a beveled lower border (Fig 1, d). The graft can then be sprung between the notch in the previous fusion below and the spinous process above. Reinforcement of the clothespin graft with iliac bone is desirable always in spondylolisthesis and generally when used in association with laminal defects. If laminal defects are



present it is necessary to set the clothespin graft as tightly down on the base of the spinous process as possible so that iliac or other chip grafts laid in along the side will not fall in the laminectomy wound and become a potential source of extradural pressure. Following its implantation an accurately fitted clothespin graft can be immediately tested for stability by grasping and shaking it with a bone holding forceps. The amount of stability secured without any other fixation is rather startling. Routine closure of the wound is carried out and a jacket used if desired.

Any spinal operation is apt to be a massive procedure and thus is no exception. Infusions and transfusions if necessary should be done.

#### CONCLUSIONS

1. A graft is proposed which by its shape and position is maintained in the spine tightly fixed in place without using extraneous material.

2. By the position and the normal mechanics of the lumbar spine the traction is secured not only of the posterior elements of the spine but of the anterior elements as well.

*NOTE*.—Since the submission of this article I have received personal communication from Dr. Alexander Gibson of Winnipeg, Canada, calling attention to an article entitled "A Modified Technique for Spinal Fusion," written by him and published in the September, 1954 issue of JG, pp. 365-366. This article clearly entitles Dr. Gibson to priority; we do not claim originality for the graft as presented but do believe that its use should be restricted to the repair of lumbar defects and for spondylolisthesis.

# RELATIONSHIP BETWEEN THE CLINICAL AND ROENTGENOLOGICAL FINDINGS IN BONE METASTASES

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IN their monograph, *The Vertebrae*, George and Leonard state "Repeated examinations lasting over a fairly long period of time may be made without finding any visible changes in the body of the vertebra that is clinically suspected"

The usual history is that, following mastectomy to remove a malignant tumor, after varying intervals of time the patient begins to suffer from pains along the sciatic nerves which are not relieved by the usual methods of treatment. A metastatic lesion is then suspected and an x-ray examination is made. Although the examination is carried out in accordance with all the rules of roentgenological technique, the result may be negative. In 1 case under my observation, a 48 year old woman, who had been operated upon for a breast cancer about a year ago, died of pneumonia 3 weeks after a roentgenological examination of the spine had revealed no metastasis. The postmortem x-ray examination of the excised vertebra was likewise negative. Even the x-ray examination of thin sections of the dried vertebrae disclosed no metastatic lesion (Fig 1). Yet, on microscopical examination cancer tissue was found in abundance (Fig 2). Thus the following triad presents itself: clinically, there is pain, microscopically, cancer, and roentgenologically, a normal appearance.

Erdheim was so impressed by the discrepancy between the roentgenographic and microscopic pictures that he developed the following theory. He assumed that, besides the osteolytic and osteosclerotic types of metastasis of bone, there is a third type of metastasis not influencing the bone in a destructive or a productive sense. Erdheim called these metastases osteoindifferent. Konrad Weiss, supporting Erdheim's theory, called them osteoneutral.

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However, the following two objections may be raised against the theory of Erdheim: (1) There are cases in which the roentgenological findings in the spine are negative but in which roentgenological findings in other bones, for instance in the skull, are positive. (2) There are cases in which the findings at the first roentgenological examination are negative, while in subsequent examinations the findings are positive.

In view of these facts, it is obviously not permissible to assume that there exists a special type of cancer tissue, supposedly indifferent to bone. Rather we should assume that there is a roentgen-negative stage in bone metastasis, comparable to the Wassermann-negative stage in syphilis. Sicard, Coste, and Belot use the term "preradiologique phase."

The occurrence of a roentgen-negative stage in the development of bone metastasis may be explained as follows. As is well known, tumor cells, brought to the bone by the blood stream via the nutrient arteries, settle primarily in the wide spaces of the spongy portion, thus the dense, compact portion of bone is affected primarily only in rare instances.



Fig 1 Left, Roentgenogram of thin sections of vertebra showed no metastatic lesion

Fig 2 Photomicrograph of section of same vertebra as shown in Figure 1 shows abundant cancer tissue

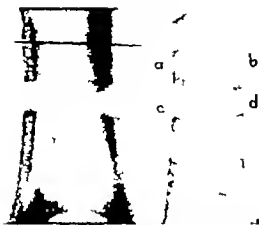


Fig. 3. Left, Tubular bone punctured by needle.

Fig. 4. Same bone as in Figure 3. a-b Canal produced by needle distinct in compact bone but no trace is visible in spongy central portion. c-d Canal made by centimeter drill plainly evident in compact bone but not visible in spongy bone.

This is probably the reason why the vertebrae being particularly rich in spongy bone are the site of predilection of metastases. It may be added that contrary to the description in many textbooks a proper firmly coherent layer of compact bone comparable to that of long tubular bones does not exist in the body of the vertebra (Jungmans).

Accordingly roentgenograms of the spine particularly lateral views, clearly show that the vertebral body consists exclusively of spongy bone. The dense ring like shadows on the upper and lower surfaces of the vertebra belong genetically to the intervertebral disc, and fuse but secondarily with the vertebra as Schmorl has shown. These shadows are less dense in persons under 15 and in the aged.

The fact that the vertebra consists exclusively of spongy bone has a decisive bearing

on the roentgenological visualization of lesions occurring within them, for the reason that, although both the spongy and the compact portions consists of calcium-containing bone tissue there is an important difference between the structures of the two parts. The spongy bone forms a wide meshwork of very thin trabeculae while the compact bone forms a thick layer of dense bone tissue. Consequently the spongy bone produces a shadow of much less density than the compact bone.

The following experiment illustrates the roentgenological consequences of this fact.

Half of a dried tubular bone consisting of both a well developed compacta and spongyosa was punctured with a needle (Fig. 3). The roentgenogram shows that the canal produced by the needle is quite distinctly seen in the compact portion of the bone while no trace of the canal is visible in the spongy portion (Fig. 4 a-b). In another experiment the same result was obtained when the canal was pierced by a drill 1 centimeter in diameter (Figs. 3 and 4 c-d). These experiments prove that a defect which is visible in a compact bone may be quite invisible in a spongy bone.

In the light of these experiments it becomes clear that lesions in the vertebrae may go undetected since, as stated, the latter consist exclusively of spongy bone. An experiment performed on a dried vertebra shows that even as many as 5 defects of varying length and width extending in cranio-caudal direction (Fig. 5) remain invisible on films taken in antero-posterior, lateral and oblique positions (Figs. 6, 7, 8) representing all the directions in which vertebrae can be examined roentgenologically *in vivo*. Similar observations have been published by Chassin in Russia, Boehmig and Previg in Germany, Snure and Maeder here



Fig. 5

Fig. 5. Illustration of dried vertebra in which 5 defects are visible.



Fig. 6



Fig. 7

Fig. 8

Figs. 6, 7 and 8. Roentgenograms of vertebra in Figure 5 taken in anteroposterior, lateral, and oblique positions.

The question immediately arises, nevertheless, why certain pathological conditions of the vertebra are well recognizable on x-ray films. Our experiments on dried vertebrae and observations on clinical cases have led to the following conclusion. A defect in the vertebral spine can be seen roentgenologically because of 2 things (1) The defect is portrayed orthoroentgenographically, that is, the rays traversing the defect are parallel to its longest axis, (2) the defect changes the contour of the vertebra

A closer analysis of the first condition reveals the following results

1 A defect produced artificially in a dried vertebra which extends through less than one-third of the vertebra cannot be demonstrated roentgenologically. If the defect exceeds one-third but does not extend through the whole vertebra, it appears merely as an area of decreased density (decalcification or rarefaction), because the remaining bone tissue still casts a shadow (Fig 9, *a, b*). To be demonstrated as such, a defect must extend throughout the whole bone in the direction of the rays (Fig 9, *c, d, e*)

2 Besides the extent of the defect, a thick-walled abdomen also has an important bearing on roentgenological visibility. In the case of a thick abdominal wall the statement of Ferguson applies, "in some spine lesions decalcification may not be recognizable because of the great thickness through which the spine is viewed." My experience has shown that if, in a given direction, the thickness of the tissues overlying the vertebrae exceeds 20 cen-

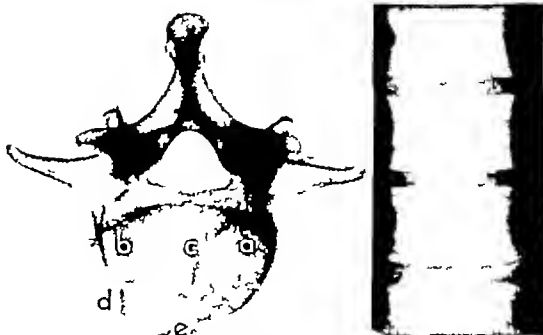


Fig 9 Left, *a, b*, Defects extending through one third of vertebra appear as areas of decreased density, *c, d, e*, defects extending through whole bone

Fig 10 Postmortem examination of excised vertebrae

timeters, only a defect affecting half the vertebra in the direction of the central ray will make its appearance roentgenologically as an area of lessened density. Lesions not discernible clinically do, however, become obvious on postmortem examination of the excised vertebra (Fig 10)

A closer analysis of the second condition—that the defect is visible because it changes the contours of a vertebra (Fig 11)—reveals the following

1 A defect which changes the contours of a vertebra can be distinguished as such roentgenologically regardless of its extent. In its initial stages the contour, usually smooth, appears blurred (Fig 12), later the contour, normally archlike, appears angulated (Fig 13). In an advanced stage the diameter of the vertebra also is reduced so that the size is changed too (Fig 14). Then not only the



Fig 11

Fig 12

Fig 13

Fig 14

Fig 11 Contour of vertebra changed so that defect is plainly visible.

Fig 12 Initial stage, blurred contour

Fig 13 Later stage, angulated contour

Fig 14 Advanced stage, diameter of vertebra is here reduced



Fig. 5. Left: Defect in dried vertebra marked by fine wire. Right: a, Lesion on left side; b, lesion on right side.

contour but the shape of the whole vertebra is altered. The most frequent deformity resulting from the collapse of the vertebra is the wedge form. A reduction of the size of the vertebra without change of its shape is very rare.

2. The thickness of the overlying abdominal tissues does not interfere with the roentgenological manifestation of a contour-changing defect. If the vertebra is presented distinctly, even the smallest contour-changing defect can be recognized roentgenologically.

The subsequent experiment illustrates the difference between the appearance of a defect of the vertebra visible because it is portrayed orthoroentgenographically and that of a defect visible because it had changed the contours of the vertebra. In a dried vertebra a defect—marked by the wire—was produced on the left side extending through its whole length in the anteroposterior direction (Fig. 15). On the right side of the vertebra a small lesion was produced transforming the nor-

mally archlike contour into an angulated one. Roentgenograms show that the lesion on the left side (Fig. 16 a) despite its extent, can hardly be seen while the small defect on the right side is distinctly visible (Fig. 16 b). In addition the lesion on the left side though extensive, would in all probability be completely undetected if the vertebra were examined through the abdomen, whereas the defect on the right side despite its smallness would remain visible roentgenologically as long as the vertebra is visible.

The conclusion to be drawn from these observations is that only in a very advanced stage can a lesion in the vertebra become visible due to its extent. On the other hand, even the smallest defect can be recognized roentgenologically if it causes a change in the contour of the vertebra. In other words, a defect seen because it is portrayed orthoroentgenographically is a *late* x-ray finding; a defect seen because it changed the contour of the vertebra is an *early* x-ray finding.

Hence the practical rule. In searching for an early sign of a spinal metastasis we should not expect to find decalcification or deformity. Let us first of all watch the contours of the vertebrae. If there is evidence of the slightest change such for instance as a blurred or angulated contour, diagnosis of a spinal metastasis may be regarded as assured.

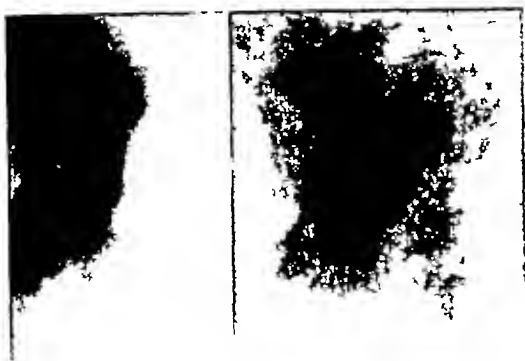
What has been said of the osteolytic metastases in the vertebra applies equally to



Fig. 7. Roentgenogram of pelvis—no pathological change evident.



Fig. 8. Same patient as in Figure 7, few weeks later showing definite change.



Figs 19, left, and 20 Pathological fracture occurred in spite of fact that roentgenogram taken a short time before revealed no metastasis

osteolytic metastases in other bones with a similar structure, namely, a well developed spongy bone with lacking or only poorly developed compacta. In this category are the ribs, the pelvis, and the metaphyseal parts of the long bones. A roentgen-negative stage exists in the development of a metastasis in these regions, during which severe pain may be present while the x-ray films do not reveal any pathological changes (Fig 17). A few weeks later, however, the x-ray film may become positive (Fig 18). In the long bones such as the femur or humerus even a pathological fracture may occur, though the x-ray films, taken a short time before, did not give the slightest indication of the presence of metastasis (Figs 19, 20).

The contrary holds true of bones with a structure opposite to that of the vertebra, that is, bones with a well developed compacta and comparatively less developed spongiosa. Here belong such parts of the skeleton as the skull and the diaphyses of the long bones. No roentgen-negative stage does exist in the development of a metastasis in these regions. Whenever clinical symptoms pointing to a metastasis are present, roentgenological signs are also encountered. What is more, metastases are roentgenologically visible in these regions even before any clinical symptoms are present. They are frequently encountered only incidentally, for instance, when one has detected spinal metastases and subsequently



Fig 21 Roentgenogram showing extension of metastases to skull

is searching for metastases in other bones. One is surprised time and again about the extension of the metastases, for instance, in the skull (Fig 21), while no pain and no other symptoms whatsoever are present.

The same holds true of the osteosclerotic metastases, regardless of their site. Osteosclerotic metastases, found with particular frequency in cancer of the prostate, may be



Fig 22 Metastases following cancer of prostate

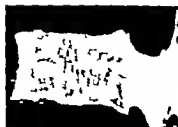


FIG. 3

roentgenologically well pronounced while clinically no symptoms are present at that time (Fig. 22). The spinal metastases are no exception to this rule. One may assume that in a spongy bone such as the vertebra an osteosclerotic metastasis produces a contrast of density to its surroundings as it normally exists in other bones between the compacta and spongiosa (Fig. 23). Therefore it is a wise procedure in cancer of the prostate to take films of the vertebrae before an operation is performed because metastases may be present in absence of any clinical symptoms.

#### CONCLUSIONS

In conclusion we may say that if we examine the relationship between the clinical and roentgenological findings in bone metastases, two groups can be distinguished:

One group comprises metastases which give clinical symptoms but are invisible roentgenologically. These may be called *roentgenologically occult* metastases. The other group of metastases may be roentgenologically visible but not cause clinical symptoms. These may be called *clinically silent* metastases.

It appears that whether a metastasis belongs to the one or the other group depends neither on the nature of the primary tumor nor upon the constitution of the patient but exclusively upon the structure of the affected bone: that is, on the relationship between the amount of the compact and spongy bone tissue.

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# PROLAPSE OF THE EFFERENT (DISTAL) SEGMENT OF BOWEL AFTER COLOSTOMY

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THE purpose of this report is to present the case histories of 5 patients in whom prolapse of the efferent (distal) segment of bowel occurred following colostomy and to discuss the etiology, pathogenesis, and treatment of this complication.

The literature contains numerous references to instances of prolapse of the afferent or proximal segment of bowel following colostomy, but reports describing this complication distal to the colostomy are decidedly infrequent. Bevis, in reporting his case of prolapse involving the distal segment, stated that he had found only 3 reports of this complication in the literature and all were in French journals (4, 10, 11). Antonioli reported 1 case in 1935. Gabriel and Lloyd-Davies, in reviewing the complications in 500 patients for whom palliative colostomy was performed because of inoperable carcinoma, reported 12 instances (2.4 per cent) of prolapse of all types. They considered it a rare complication and stated that it usually takes place from the upper opening, occasionally from the lower opening, and sometimes from both. Veal in 1940 reported 4 instances of prolapse of the sigmoid colon following colostomy. The lower segment was involved in 3 of the 4 patients.

The following case reports and illustrations present the outstanding aspects of this type of prolapse.

CASE 1. C. G., a 44 year old unemployed colored painter, was first admitted to the Louisiana State University surgical service in the Charity Hospital at New Orleans on March 3, 1939. At that time a tumor mass which almost completely occluded the rectal lumen was found, and the diagnosis of carcinoma of the rectum was verified by examination of a biopsy specimen. On March 22, 1939, under spinal anesthesia, the abdomen was opened and exploration disclosed widespread peritoneal seeding

A simple loop colostomy, in which the sigmoid colon was used, was made through a left McBurney incision. The wound healed without infection. The colostomy was opened on the 15th day after operation, it functioned well and the patient was discharged on April 11, 1939.

On May 1, 1939, he was readmitted for radiation therapy. His condition was essentially the same as on the previous admission. On the morning of the 3d day in the hospital, while the patient was getting out of bed, the distal loop of the colostomy prolapsed. The picture shown in Figure 1 was taken within the next 2 hours. The prolapse was reduced in the usual manner (Fig. 2). There was no recurrence although the stenosis in the rectum persisted. Ascites and general weakness developed and the patient died at his home on June 14, 1940, about 15 months after first admission. No autopsy was done.

CASE 2. E. D., a 30 year old colored female cook, was first admitted to the Louisiana State University surgical service of the Charity Hospital of New Orleans on August 19, 1940, with the chief complaint of constipation of 2 years' duration. She was found to have a firm annular stricture of the rectum and a diagnosis of rectal stricture due to lymphopathia venereum was made. On August 24, 1940, a simple loop colostomy was made, the sigmoid colon being used. It was opened 3 days later and functioned well from the beginning. The patient was discharged on September 9, 1940.

The patient was next admitted on October 21, 1941, because of prolapse of the distal loop of the colostomy. The protruding segment of bowel was then about 3 inches (7.5 cm.) long. Because of a strongly positive Wassermann reaction, repair of the prolapse was deferred. The bowel was undisturbed and the patient was discharged with provisions for a course of antilutetic therapy.

When the patient was readmitted on February 3, 1941, the prolapse had increased in size (Fig. 3) and, according to the history, had been almost 8 inches (20 cm.) long at times. The prolapse was reduced. Because of extensive rectal and perirectal involvement, an abdominoperineal resection of the rectum was done, a stump of sigmoid being left distal to the colostomy. This stump was turned inside out and protruded from the colostomy stoma in the same manner as had the prolapse. Five days later the protruding portion of bowel was freed from the abdominal wall, the layers of which were then closed snugly about the proximal loop making an end type of colostomy. The excess bowel was removed with cautery. The end result is shown in Figure 4.

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Fig. 1. Case. Prolapse of the distal segment of left internal loop colostomy. The opening at the proximal segment is plainly seen. The prolapsed portion is often and edematous.

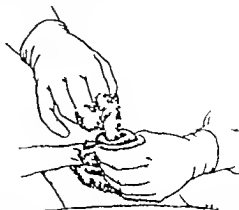


Fig. 2. Reduction of the prolapse is accomplished in this manner. The maneuver is essentially the same as that employed in reducing rectal prolapse. With the exception that, due to its length, the prolapsed bowel must be supported. The use of dry gauze as illustrated facilitates the reduction.

CASE 3. A. B., an unemployed 9 year old colored girl, was admitted to the Louisiana State University surgical service in Charity Hospital at New Orleans on February 26, 1941 because of almost complete lower bowel obstruction. Anular stricture was found about 5 centimeters above the anal orifice. At this point the lumen of the bowel admitted nothing larger than No. 10 urethral catheter. The Frei test was positive. A diagnosis of rectal stricture due to lymphopathia venereum was made. Because of the obstruction it was necessary to make colostomy the sigmoid loop being the site selected. This was done on March 5, 1941 under general anesthesia. The colostomy was opened 8 days later the wound healed without infection. One week later the patient was discharged from the hospital.

The patient was readmitted on April 6, 1941 complaining that the bowel had fallen out and was painful. The distal loop of the colostomy was found to be prolapsed as shown in Figure 3. The prolapse was about 5 centimeters long engorged and edematous. It was reduced and within the next days there were 4 small bowel movements through the rectum. A flat gauze dressing was applied over the colostomy stoma and held in place by wide support of dion tape. The patient was allowed to be up and was discharged a few days later.

On May 9, 1941 the colostomy toms was almost completely closed (Fig. 4). The bowels were moving through the rectum although the stricture was essentially unchanged. Similar findings were present on August 1, 1941.

CASE 4. R. S., colored female age 34 years, was admitted to the Louisiana State University surgical service of Charity Hospital at New Orleans on April 8, 1941 with the chief complaint of constipation, rectal pain, and passage of blood and pus per rectum.

Examination revealed complete anular stricture of the rectum about 6 centimeters from the anal orifice. The lumen of this point was less than 1 centimeter in diameter. A diagnosis of rectal stricture due to lymphopathia venereum was made and on April 29, 1941 the first stage of modified Labret procedure was done the distal stump of bowel being implanted in the lower end of the left rectal colon. A ureter cath recovery followed and the patient was discharged on May 30, 1941.

On the second admission July 1, 1941 the patient complained of recurrent protrusion of the lower segment. The exposed mucosa was very edematous and bled easily when manipulated. The prolapse was reduced manually (Fig. 5) and remained reduced after resumption of restricted activities. On the 2nd and 3rd July 6, 1941 the second stage of the resection was done. The patient was discharged on August 7, 1941. She was seen on August 7, 1941 and reported gain of 5 pounds and considerable increase in strength and appetite. The colostomy functioned satisfactorily and the anterior and posterior ends of the bdominopelvic resection are solidly healed.

CASE 5. L. W., colored female age 50 years, was admitted to the Louisiana State University surgical service of the Charity Hospital at New Orleans on March 24, 1940, complaining of rectal pain, constipation and sanguinopurulent discharge from the rectum. An anular stricture of the rectum was found on digital rectal examination but the proctoscopic examination through which blood and pus drained, as found to be 2 centimeters below the anal orifice. Moderate hypochromic anemia was present. The Frei test was reported to be negative. A barium enema disclosed an irregular filling defect compatible with diagnosis of carcinoma, but



Fig 3 Left, Case 2 Prolapse of the distal segment after simple loop colostomy The proximal loop shows a mild degree of prolapse also

Fig 4 Case 2 The end result following abdominoperineal resection of the rectum and plastic repair of the colostomy

biopsy specimens from the area failed to substantiate this impression. On March 15, 1940, a laparotomy was performed. The findings suggested that the mass at the rectosigmoid junction was due to inflammation rather than neoplasia. The adjacent mesosigmoid was shortened and thickened. A modification of the Lahey procedure was done. Recovery was uneventful, and the patient was discharged on March 23, 1940.

The patient was next admitted on August 23, 1940, complaining of prolapse of the distal loop of the colostomy. During the interval, the colostomy had functioned satisfactorily. Considerable pain had been present, however, since the onset of the prolapse. The blood picture had definitely improved. On September 6, 1940, under general anesthesia, the stump of the distal loop was freed from the abdominal wall and the peritoneal cavity was entered. The mass at the rectosigmoid junction had decreased in size and the subsidence of inflammation in the mesosigmoid had left that structure thinner and longer resulting in increased motility of the sigmoid. The distal loop was drawn taut and the abdominal wall was closed snugly about it. After healing had taken place the protruding portion of the bowel was removed with the cautery. Although a mild mucosal prolapse persists the patient has been free from discomfort and pain.

#### ETIOLOGY AND PATHOGENESIS

The etiological factors in prolapse of the distal segment of bowel after colostomy may be arranged as follows:

- 1 Excessively large defect in the abdominal wall due to (a) failure to close the abdominal wall snugly about the protruding loop of

bowel, (b) loss of tissue from the edge of the defect in the abdominal wall because of infection and sloughing, (c) relaxation of the abdominal wall in patients with atrophic or atonic tissues.

- 2 Redundant bowel due to (a) Lengthening of lower segment because upper segment usually is drawn so taut that it cannot prolapse, (b) resolution of inflammation in either shortened bowel or mesosigmoid below the colostomy site which may be followed by increase in length and motility of the distal segment.

- 3 Obstruction of lower segment

- 4 Increased intra-abdominal pressure

It is obvious that a combination of factors is concerned in the development of prolapse. However, the factor which has been considered to be most important by some authors is the size of the opening in the abdominal wall. This appears to be especially significant in the Maydl-Reclus type of loop colostomy in which the two limbs of bowel pass through a common defect. Most of the reported instances of prolapse (1, 2, 4, 10, 11, 14) and 3 of the 5 cases described in this report have been complications of this type of colostomy. Weakness of the abdominal wall is commonly seen as a part of general weakness and debility in patients with advanced carcinoma of the rectum or long standing lymphopathia ven-



Fig. 5. Left, Case 3. Prolapse of the distal segment after loop colostomy for high grade obstruction caused by rectal stricture.



Fig. 6. Case 3. After reduction of the prolapse and a period of bed rest contraction about the colostomy resulted in its almost complete closure (libla 6 recta).

ectum with rectal stricture and secondary infection. The size of the defect may permit a mild degree of prolapse initially, but the stretching effect of the protruding bowel often enlarges the defect so that prolapse recurs or persists. The opening in the abdominal wall may become too large due to loss of substance from the edge as a result of infection and sloughing. Unfortunately this is likely to happen in the group of patients who already have relaxed or thin abdominal walls or both so that a gaping defect is the end result.

Redundancy of the distal segment of bowel and mesosigmoid is a necessary, but not the sole factor in the development of prolapse. The common practice of rendering the proximal segment taut to prevent prolapse of that part of the bowel when making a simple loop colostomy of the Maydl Rectus type leaves the distal portion long enough to prolapse. The degree to which such a segment will prolapse depends to some extent on the length of the mesosigmoid. This point is well illustrated by Case 5 in which an inflammatory lesion obstructed the rectum and involved the mesosigmoid shortening and thickening the latter. Prolapse did not occur until 5 months after the colostomy had been made. When

the prolapse was repaired the inflammatory process was found to have subsided considerably and thinning and elongation of the mesosigmoid had occurred. Along similar lines Loubat and Fontain describe a patient with complete stenosis of the rectum due to inoperable carcinoma. In performing colostomy it was barely possible to bring the sigmoid through the abdominal wound. No difficulty was encountered from prolapse in this instance although the stenosis remained complete.

Obstruction of the lower segment (usually in the rectum) was a prominent feature of many of the reported cases (4 to 11 14). In all of the cases described in this report the rectal lesion, whether carcinoma (1 case) or rectal stricture due to lymphopathia venereum (4 cases) caused almost complete obstruction of the rectum.

The rôle of increased intra abdominal pressure is difficult to evaluate as a single factor, but in combination with a gaping defect in the abdominal wall prolapse may be initiated in much the same way as the hernia in certain forms of hernia.

In the absence of a gaping defect in the abdominal wall the actual mechanism of pro-

lapse of the distal segment of bowel is similar to that of intussusception as Veal points out. Discharges from an ulcerated lesion or quantities of mucus accumulate in the rectum and because of obstruction reversed peristalsis occurs. This everts the redundant portion of the bowel through the fixed part (at the colostomy site). The prolapsed bowel, which represents the intussusceptum, escapes through the colostomy stoma instead of being enclosed by the intussusciptiens as occurs in the usual process of intussusception. In prolapse, therefore, there is no intussusciptiens. For the sake of clarity in describing the operative correction later on, the prolapsed portion of bowel may be called the intussusceptum and therefore quite properly can be said to have an inner and an outer layer.

The fully developed prolapse measures from 15 to 20 centimeters in length. The diameter varies from 3 to 7 or 8 centimeters depending upon the degree of interference with the circulation. Within a few hours after the prolapse the bowel becomes edematous, the mucosa is shiny and is covered with mucus. As the return of venous blood is interfered with, the bowel becomes so engorged that it bleeds readily when manipulated. If allowed to remain unreduced the prolapse may become irreducible and circulatory changes leading to ulceration and gangrene may occur. In some instances the size of the prolapse is such that it obstructs the proximal segment completely and manifestations of intestinal obstruction may appear. There is usually some pain or discomfort associated with prolapse, but as a rule it is not severe.

#### TREATMENT

The most important prophylactic measures concern efforts to control the size of the defect in the abdominal wall. Toward this end, particular attention should be directed to fitting the edges of the incision snugly about the loop of bowel. In these patients who so often are in poor general condition, the careful observance of the points in wound healing as emphasized by Whipple and Reid (12) is especially important in securing primary healing. Thus, if time permits, any existing anemia, hypoproteinemia or vitamin deficiency,

particularly lack of vitamin C, should be corrected prior to operation.

Every effort should be made to avoid infection as it may be followed by sloughing which results in an unnecessarily large opening. The possibility of infection may be decreased by minimal manipulation of the bowel and by completely avoiding the use of sutures in any layer of the bowel wall, fibrinous exudate being allowed to attach the bowel to the wound edges.

The substitution of a flexible rubber tube for the glass rod so commonly used in preventing the retraction of the loop of bowel in the Maydl-Reclus type of colostomy may prevent the development of an area of pressure necrosis in the bowel at the mesenteric border should abdominal distention develop. Leaking through such an area of necrosis often allows concealed contamination of the wound and serious infection may develop.

Since rendering the proximal segment of the sigmoid taut in making a Maydl-Reclus type of colostomy has been so effective in preventing prolapse of the afferent loop, the possibility of similarly caring for the distal segment has been considered. This would necessitate the exteriorization of a relatively long segment of bowel which would ultimately require removal, a sort of Mikulicz procedure. As Loubat and Fontain pointed out, the low incidence of a relatively benign complication (prolapse) does not warrant substituting this more formidable procedure for the simple one of constructing a loop colostomy.

Following the construction of the colostomy causes of increased intra-abdominal pressure, such as chronic cough, straining at urination or defecation, lifting heavy objects, or other similar exertion, must be avoided or kept at a minimum. A colostomy in reality represents a defect in the abdominal wall which is plugged by a loop of bowel. Even when the "plug" fits snugly into the defect the site of the colostomy is a weak area which does not withstand intra-abdominal pressure as well as the intact abdominal wall. Under the influence of increased intra-abdominal pressure the loop of bowel may dilate the defect in the abdominal wall in a manner similar to the omental wedge which is frequently an im-

portant factor in the development of hernia.

The prolapse may be treated palliatively by reduction as shown in Figure 2. The patient is given appropriate doses of morphine to aid in relaxation of the abdominal musculature after which reduction is usually not difficult. Elevation of a markedly swollen prolapsed bowel may be followed by some decrease in size. Rather firm pressure if applied uniformly to the apex of the prolapse may so decrease its size that reduction may be initiated and once started, no difficulty is usually encountered in completing it. After reduction the patient should be kept in bed for several days and when allowed to be up should wear a flat piece of gauze instead of a colostomy bag over the colostomy stoma. In addition a wide abdominal support should be worn. Early reduction as in Cases 1 and 3 will prevent stretching the defect in the abdominal wall and thus guard against recurrences.

The radical treatment of prolapse varies considerably. Plastic procedures designed to correct a gaping defect in the abdominal wall may be successful occasionally but often fail because of wound infection or because of poor wound healing in an area in which previous infection has resulted in considerable scar tissue. However should this type of repair be followed by satisfactory healing, the redundant distal loop and stenosis which remain uncorrected make recurrences very probable.

Amputation of the prolapse is the most frequently practiced method of treatment. The procedure employed is exactly like that advocated by Mikulicz for the correction of complete prolapse of the rectum (3) and consists of amputating the intussusceptum near the surface of the skin only enough cuff of outer layer being left to suture to the open end of the inner layer. As the division of the inner layer proceeds the resulting proximal free edge is sutured to the cuff of outer layer to prevent retraction. The completion of this row of sutures which has approximated the serosae of the inner and outer layers closes the peritoneal cavity. By division of the outer layer of the intussusceptum near the skin an adequate blood supply to the remaining narrow cuff of bowel is assured and, at the completion of the operation the suture line is held

at the level of the skin. A longer outer cuff may have poor blood supply and, should the site of anastomosis finally rest inside the peritoneal cavity a leak from the suture line may lead to generalized peritonitis. This series of events led to the death of Charbonnel's patient whereas the usual type of repair with the suture line at the level of the skin was entirely satisfactory in cases reported by Davis, Loubat and Fontain and Madrange.

The procedure of ligating the intussusceptum about a hard rubber tube placed in its lumen has been applied to complete prolapse of the rectum (13) and to prolapse of the afferent segment of bowel in a loop colostomy by Hall. Although rather severe cramp-like abdominal pain occurred after the ligatures were applied in Hall's case the treatment was successful the intussusceptum coming away 3 days later and complete healing followed without infection or hemorrhage just as in the cases of complete prolapse of the rectum reported by Reid (13).

Veal reports an instance of fatal peritonitis following cauterly excision of what was thought to be a prolapse of mucosa at the site of a loop colostomy. Because of this experience Veal has proposed a two stage operation. The first stage is carried out through a left rectus incision opposite the colostomy site and consists of attaching the serosa of the outer layer of the intussusceptum to the serosa of the inner layer by means of a series of interrupted sutures placed at the level of the parietal peritoneum. This seals off the peritoneal cavity from the potential space between the inner and outer layers of the intussusceptum and after several days the second stage of the operation, which is essentially the Mikulicz procedure for complete rectal prolapse is done.

The plan of radical treatment will of course depend on the type of colostomy. If prolapse occurs in the distal segment after a defunctionalizing colostomy of the Lahey or Devine type the prolapse may be attacked directly as it has already been protected from gross and continuous contamination and post-operatively will not be subjected to this hazard. The prolapse in the fifth patient was managed in this way.

Undoubtedly many fatalities following surgical treatment of the prolapsed distal segment of a loop colostomy have remained unrecorded as only Veal's and Charbonnel's cases were found in the literature. From the experiences of Bevis, Loubat and Fontain, and Madranges the direct attack on the prolapsed segment appears to be satisfactory. In the future it is possible that the risk of peritonitis in these cases may be lessened by the use of chemotherapeutic agents (6).

Although 2 of the cases of prolapse in this series were treated by abdominoperineal resection it should be emphasized that such radical procedure is not advocated for prolapse *per se*. In the cases thus treated the primary object was to remove a focus of infection for which all previous treatment had been unsuccessful. The correction of the prolapse was of secondary importance.

#### SUMMARY AND CONCLUSIONS

- 1 Prolapse of the efferent segment of bowel through a colostomy is rare
- 2 The important etiological factors are the size of the defect in the anterior abdominal wall, the redundancy of the bowel distal to the colostomy, stenosis of the distal segment, and increased intra-abdominal pressure

3 The prevention of prolapse begins with measures to control the size of the defect in the abdominal wall. The palliative treatment includes manual reduction of the prolapse and the use of support to prevent its recurrence. Radical treatment includes plastic procedures to decrease the size of the defect in the abdominal wall and immediate or delayed amputation of the prolapse in either one or two stages.

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# EXPERIMENTAL CRUSHING INJURY

## Peripheral Circulatory Collapse and other Effects of Muscle Necrosis in the Rabbit

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THE syndrome culminating in renal failure seen in air radd casualties following prolonged compression beneath debris has been thought on clinical grounds to be the result of muscle necrosis (Bywaters and Beall 1941). As soon as the picture had been clearly defined in man we decided to reproduce the condition if possible experimentally. The method used at first of which this paper is an account was only partially successful only one aspect of the human condition was reproduced. This failure to reproduce the full picture might possibly be accounted for by the fact that the muscles of the experimental animal used did not contain myohemoglobin. Although disappointed at first we may have gained a distinct advantage in that the complex problem has been split for analysis into two natural parts, first, those effects that have in man been classified as circulatory collapse and second the effects classified as renal impairment. Other methods have been developed to reproduce renal failure. This paper is confined to the study of a shock syndrome produced in the rabbit by muscle necrosis. A second paper will deal with the experimental production of renal failure following myohemoglobin injection.

In man almost any serious collapse result ing from burning bleeding cutting crushing hurting freezing or frightening, may be given this label shock often to the stultification of detailed observation. In the realm of experiment even greater diversity of means is thought to result in this single end shock. It should be recognized that each type of

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trauma produces specific results and that the clinical syndrome called "shock"—pallor sweating coldness, and a decreased arterial pulse—is only a part of many diverse processes set in motion by various types of trauma, conspicuous because common to all. The advantage therefore of experimental inquiry over clinical observation is that trauma can be produced by a single simple and controlled process, thus rendering analysis easier. A common method of producing experimental shock is to beat with a blunt instrument, a limb under general anesthesia; this produces soft tissue damage hemorrhage and usually fractures as well, with concomitant fat embolism besides introducing the added complication of a prolonged anesthesia. The mode of production of shock described here is limited to a single main causal factor muscle necrosis decrease of circulating blood volume can be produced and measured without hemorrhage or fracture without pain as far as this can be judged, and without, or with a minimum of preliminary anesthesia. Finally the results of the method are directly applicable to a similar condition in man.

### METHOD

Hollow rubber pressure tubing of 3.5 millimeter internal diameter and 7.5 millimeter external diameter was wound tightly around one or both thighs of rabbits between 1.5 and 2.5 kilograms starting at the knee and winding upward as high as thought desirable. The ends were then fastened in a screw clip. There was no further traumatization other than this tight binding. The length of leg encircled was then measured medially and laterally and the circumference was obtained by marking a strip of paper passed around the bound part at its middle. The volume of muscle included

in this cylinder was calculated by subtracting from the total volume the volume of (1) the rubber tubing in its stretched state (a factor of the measured circumference and the number of turns used) and (2) the bone beneath (a factor of the length of leg enclosed). The animal was left for any desired period, after which the rubber tubing was removed. This removal appeared to be quite painless. Anesthesia was not needed for the application, since this appeared to be as relatively painless as in man, but we found that light ether narcosis facilitated rapid application of the tubing in the standard manner. It was not prolonged for more than a minute, and had no evident effect on the animal.

The animals were kept on a standard diet, consisting of 100 grams daily of a mixture of bran (2 parts) and dried beet pulp (1 part) moistened with 250 cubic centimeters of water, and were allowed to drink water freely, they were housed in metabolism cages at a fairly even room temperature (about 20 degrees C) maintained during the winter months by central heating, the urine was collected either 24-hourly (with a few drops of toluene) or for shorter periods, for most of the experiments the urine was expressed by pressure on the belly at the desired time. Blood was obtained from the ear veins to obtain serum free from hemolysis it was necessary to centrifuge before coagulation.

Biochemical analyses were performed by the following methods: blood urea, plasma chloride, phosphate and protein (King, Haslewood, and Delory, 1937), serum potassium (King, Haslewood, Delory and Beall, 1942), carbon dioxide combining power (Van Slyke and Cullen, 1917), urine protein (King and Haslewood, 1936), urine creatine and creatinine (Folin, 1914), urine urea (classical urease and nesslerization method), urine hydrogen ion concentration by a capillary tube method, using the British Drug Houses 4-11 indicator and then more specific ranges such as given by bromcresol purple, hemoglobin by the photoelectric method described by Hill and Pincock, 1941. Blood pressure was measured on the central ear artery by the capsule described by Grant and Rothschild (1934), care being taken to ensure full dilata-

tion of the vessels with heat. Changes in extracellular tissue fluid volume (thiocyanate space) have been followed in four experiments, the change in final serum concentration of injected sodium thiocyanate being used, estimated as described by Lavietes and associates (1937) except that the serum was withdrawn without oil allowance was made for the amount excreted in the urine. Permeability was investigated by the intravenous injection of trypan blue, 1 or 2 per cent solution in normal saline being used, the dosage varying between 50 and 200 milligrams per kilogram.

Autopsy was performed immediately after the animal was killed by a blow at the back of the neck. Tissue fluid was collected from the leg after removal of the skin, and, in some instances, the amount of necrotic tissue was measured volumetrically after dissection. Heart blood was also taken and urine was collected. The adrenals and kidneys were dissected free and weighed. Tissues were fixed in 5 per cent formol-saline and 5 per cent formol-Zenker.

#### RESULTS

After some orientating experiments in which the effect of compression for various times and of a varying extent of muscle was observed, a procedure was standardized for subsequent work on muscle necrosis and renal function. This was a compression of 4 to 6 hours by 8 turns of the rubber tubing. Most of the results given below apply to such a procedure, but, as will be seen when the effects of a varying time and extent of compression are discussed, it does not seem to matter whether compression was maintained for anything from 4 to 12 hours, within these limits the result is very similar. Further, while, with the standardized procedure, similar results were obtained in general in each experiment, yet there was considerable individual variation in quantitative detail. We have therefore selected, for illustration, typical examples of each type of experiment.

During the period of compression, the animal remained well. The blood urea might rise or fall a few points within normal limits, the blood pressure remained constant, the hemoglobin might rise or fall slightly, perhaps due to leakage of plasma into, or from, the





Fig. Rabbit post mortem showing extent of muscle necrosis following the standard procedure (8 turns of tubing applied for 3 hours). The rabbit was killed 7 days after release. Not the sharp border and small petechial hemorrhages. Most of the edema has by now been absorbed.

compressed area. There might be a diuresis during this period when the urine became dilute and more alkaline. Only on rare occasions did a slight trace of albumin or creatine appear (for the first time) in this urine doubtless due to leakage from the compressed area.

*After release of the compression.* 1. *General observations.* Immediately after release the compressed muscle was smaller than the opposite side, cold and relatively hard to touch. The leg below the lesion was usually normal. Soon within an hour the compressed muscle began to swell and become doughy, pitting on pressure was felt afterward and in the course of a day spread downward to affect the limb below the lesion and upward toward the groin. The limb was paralyzed and as the animal hopped round it was dragged behind. Usually the animal recovered sufficiently to eat and drink within 6 hours of release, but its appetite was seldom normal for the first day. Recovery of the limb was never complete as regards use owing to atrophy, but edema had usually disappeared by 2 weeks, often there was atrophy, not only of the adductor group and the lower quarter of the quadriceps, but also of the calf muscles as well.

Animals compressed for a time shorter than 2 hours were less incapacitated, showed much less edema and were not paralyzed; there was practically no atrophy. Similarly all changes were less marked in animals in which the extent of the compression had been less (e.g.

2 turns of rubber tubing instead of 8 as in the standard procedure). Animals compressed for 12 hour periods showed no greater change than did those compressed for periods of 4 hours. If however the extent of the damage was increased by repeating the standard compression on the opposite limb at the same time, or within a day, death occurred in "shock" with a low blood pressure. Degrees of damage intermediate between this and the standard procedure produced intermediate results. Rarely death occurred after compression of one limb in which a greater quantity of muscle had been damaged than in the standard procedure. In 40 experiments in which one limb was crushed by the application of 8 to 10 turns of tubing (i.e. 1 to 2 milliliters of necrotic tissue per 100 grams body weight) for periods varying between 3 and 12 hours, but mostly of the standard time 4 to 5 hours only 3 died. Details of these follow.

2. *Pathology.* Pathological changes were seen postmortem in the muscles, only slight changes in the kidneys and adrenals, and little elsewhere. In summary there was subcutaneous edema in animals surviving several hours, extending from the toes up over the belly wall and into the rump, often extending as well into the opposite rump. The muscles were swollen and edematous, unusually pale and friable from the first or second day on, with a well marked line of demarcation (Fig. 1). There was no hemorrhage other than occasional petechiae, most numerous in the boundary zone between living and dead tissue. Necrosis occurred in the majority of animals, only beneath the compressing band. A circulation adequate to supply the distal part of the limb is probably maintained through the femoral marrow spaces. This may explain why it is usually impossible to produce necrosis with a single ligature except immediately beneath it, unless the tubing is applied (as in Wilson and Roome's work in the dog) actually around the leg at the level of the hip joint. This procedure would minimize the circulation through the femur. In only 3 of 40 one leg crush experiments was there necrosis distal to the compression (in the gastrocnemius, soleus and anterior tibial muscles). Two of these 3 animals and 1 other rabbit with highly



Fig 2

Fig 2 Trypan blue injection in rabbit crushed by standard procedure. Note subcutaneous bluing and edema extending down to foot and up over reflected flap of abdominal skin.



Fig 3

Fig 3 The same rabbit, with subcutaneous tissue removed from leg, showing muscle necrosis and bluing ex-

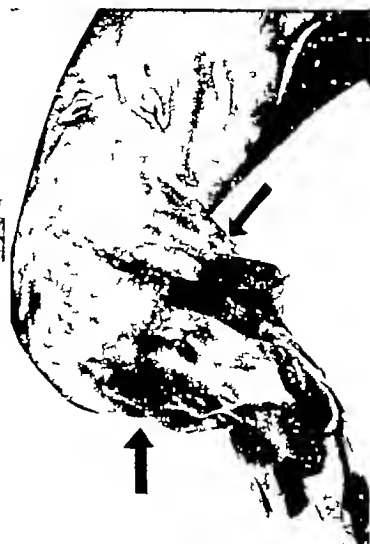


Fig 4

tending a small distance above and below the necrotic area.

Fig 4 The same rabbit with muscle incised to show the sharp boundary between intense blue stained necrotic tissue and more normal edematous tissue nearby only lightly stained.

acidified urine and blood were the only ones that died following compression of 8 to 10 turns on one leg for 4 hours and upward. It is thought that vasospasm was responsible for this necrosis. Barnes and Trueta (personal communication) have demonstrated that this does occur in rabbits with single light wire ligatures round the thighs. In favor of this, as an explanation, was the character of the necrosis in the distal muscles, which was rather patchy, without any definite gross demarcation zone between living and dead tissue such as was seen beneath the compressing bands. In 7 experiments, trypan blue was injected intravenously to delineate the damaged area. In 1 rabbit weighing 1800 grams, into which 70 cubic centimeters of 2 per cent trypan blue in saline had been injected 6 minutes before release, the blue area seen at postmortem 40 minutes after release corresponded exactly with the area over which rubber tubing had been applied, above and below there was no increase in permeability. When the necrotic area was directly observed in an anesthetized animal injected with trypan blue immediately after release of the compres-

sion, the dye was seen in the large blood vessels running through the crushed area to the distal part of the leg within a few seconds of injection. The compressed area, white compared with the pink normal muscle proximally and distally, only gradually became distinctively colored. The blue appeared first surrounding the larger branches of muscle arteries at about 15 minutes after release, and was only distinctly visible over the whole area after 30 minutes. When injected later, for instance 20 minutes after release, the coloration was much less rapid. In the late stages of the lesion, for instance a week after release, the dye was most intense in the boundary zone between the normal muscle and the central white "infarct" of necrotic and coagulated fibers. At 20 hours after release of compression and simultaneous trypan blue injection, there was much blue dye not only in the necrotic area but in the subcutaneous edema fluid extending up over the abdomen into the rump and down to the toes (Figs 2, 3 and 4). The fluid contained dye in a concentration equal to that in the plasma. The result of these injections was taken to indicate

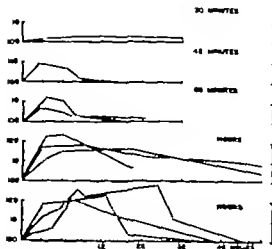


FIG. 5. Hemococoncentration following application of rubber tubing (8 turns) for varying periods expressed as percentage rise from initial value.

a local increase in permeability of the vessels in the damaged area and lymphatic drainage of the protein-dye combination. No general bluing was seen other than in liver and renal cortex, thus presenting no evidence for a generalized increase in capillary permeability. In the acute stage the internal organs appeared dry; there was no hyperemia.

In animals allowed to recover atrophy was pronounced; this sometimes affected the distal part of the limbs as well as the compressed area. It is thought that this was due to a nerve lesion as no evidence of necrosis was seen distally in the majority of the experiments.

3. *Hemococoncentration*. Immediately after release the hemoglobin percentage began to rise due to loss of plasma into the damaged area. Figure 5 shows the time relation of this hemococoncentration. There was a rapid rise in the first hour to reach a plateau, which was usually maintained until between 10 and 20 hours. There might be a peak any time during the second or succeeding hours usually between 1 and 4 hours after release. After this plateau the hemoglobin fell away to normal as the lost volume was restored. In 1 experiment (of a total of 21) in which a reading was made at 1 hour after release rises of between 10 and 20 per cent were seen with an average rise of 18 per cent; the same average figure



FIG. 6. Hemococoncentration (as percentage rise) and blood pressure (B.P. in mm. Hg.) in rabbit with both legs compressed for 8 turns, one treated with 5 intravenous saline injections of 20 milliliters each. Death occurred in each at the point indicated by the cross.

was found at 1 hour in 7 experiments in which both legs were compressed (group B1).

If the compression was applied for about 8 to 10 turns on each leg 7 of 7 untreated animals died between 4 and 26 hours after release. Even intravenous injection of saline (5 animals) or rabbit serum (4 animals) made no difference in the results except in one animal which survived longer than usual and died between 42 and 48 hours. Figure 6 compares the hemococoncentration and blood pressure fall in this animal with the animal surviving longest of the untreated group. Saline given early before hemococoncentration has reached a maximum appeared to maintain blood volume at a higher level as judged by hemoglobin concentration. If given later when hemococoncentration was well established, it made little difference. Despite the maintenance of blood volume as judged by hemoglobin level the blood pressure showed as

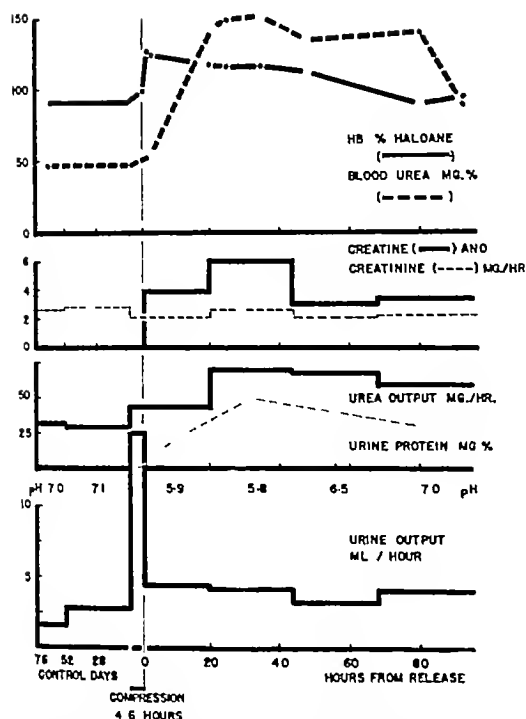


Fig 7 Part of both thighs compressed for standard time shock, although pronounced, was not severe enough to produce death. Note the acid urine, the rise in urea and hemoglobin, the increased output of urea and creatine and the maintenance of renal function

great a fall as in untreated animals, and death finally occurred. A rough analysis of the height and time of appearance of the peak hemoconcentration shows little difference between these fatal experiments (with an average calculated amount of necrotic tissue equal to 3 to 4 milliliters per 100 grams body weight) and those experiments in which one leg only was crushed (with an average calculated amount of necrotic tissue equal to 1 to 2 milliliters per 100 grams body weight). Similarly, hemoconcentration seems to bear no obvious relation to the mortality in the 4 experiments in which an intermediate amount of muscle was damaged (group C). Figure 7 shows one of these experiments, in which one leg was crushed in the routine way with 8 turns of rubber tubing, and the opposite leg bound with 3 turns only, resulting in an estimated amount of necrotic tissue equal to 2.4 milliliters per 100 grams body weight. (Actual

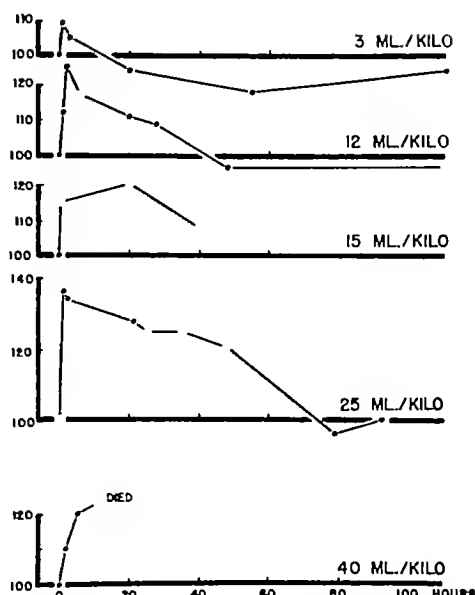


Fig 8 Hemoconcentration (expressed as percentage rise from control value) in rabbits compressed to a varying extent for the standard time

volume measurements of the necrotic edematous tissue 4 days afterward gave a figure of 2.8 milliliters per 100 grams). It will be seen that the maximum hemoconcentration is +36 per cent, this is higher than the percentage reached by 11 of the whole fatal group in which both legs were compressed for 8 to 10 turns each.

On the other hand, in a group of 5 experiments (group D) in which the one leg was crushed to a lesser extent than normal, 2 to 4 turns, resulting in an estimated necrosis of 4 to 14 milliliters = 0.2-0.7 milliliters per 100 grams body weight, and an actual measured necrosis of 0.2-0.8 milliliters per 100 grams, the hemoconcentration tended to be smaller and proportional to the amount of tissue damaged, as may be seen in Figure 8. The peak tended to be earlier, between 1 and 2 hours, as well as lower.

In a similar way, hemoconcentration was small and limited, both in height and duration, in a further group of 8 experiments (group E) in which compression was applied to the full extent but for shorter periods, from 30 minutes to 2 hours. Some of these are illustrated in Figure 5.

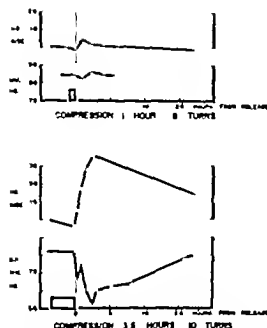


Fig. 9. The effect of 5-hour period of compression on hemoglobin and blood pressure with similar extent of injury.

**4. Blood pressure.** The systolic pressure in the ear artery might fall rapidly after release but was usually maintained until after hemoconcentration had occurred. With the standard procedure a moderate fall of 10 to 20 millimeters of mercury might occur which was held for about 20 to 30 hours. Not infrequently there was little or no fall despite the usual degree of hemoconcentration. There appears to be no direct correlation between the extent of the blood pressure fall and the degree of hemoconcentration; the duration of the two is better correlated.

With lesser amounts of damaged muscle no fall of blood pressure occurred corresponding to the very small hemoconcentration in such experiments (Fig. 9). With greater extent of necrosis, as after compression of both legs there was usually a dramatic fall in blood pressure (Fig. 6). This could be partially restored toward normal with intravenous saline but the beneficial effect was only very temporary. With 8 to 10 turns on each leg there was a progressive fall of blood pressure until death occurred.

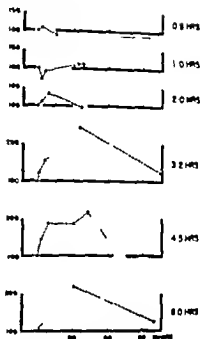


Fig. 10. Blood urea rise with compression for periods varying from 5 to 6 hours.

After compression for shorter periods than 3 hours there was little or no fall in blood pressure; this appeared to occur only when hemoconcentration approached that point seen following the standard procedure (and as pointed out above not always then).

**5. Blood urea.** The blood urea concentration rose after release of the compression but not as rapidly as did hemoglobin. The peak concentration occurred between 20 and 40 hours after release from a normal level in the rabbit with unrestricted water intake of about 25 to 45 milligrams per cent and in rabbits kept on restricted fluid intake of 30 to 60 milligrams per cent the blood urea rose following the standard procedure to a maximum of between 50 and 50 milligrams per cent, averaging about 100 milligrams per cent. It then fell away more slowly than it rose (Fig. 10).

As will be detailed later there was no obvious failure of the renal tubules in concentrating urea, and the urinary urea output was usually greater than in the control period; we must therefore ascribe this increase in blood urea at least in part to increased tissue break

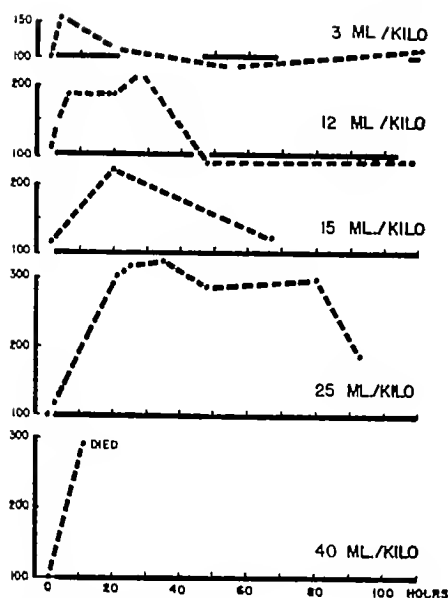


Fig 11 Blood urea rise with compression of varying extent for the standard time

down. Other factors concerned may be decreased renal blood flow and decreased filtration pressure, particularly in the rabbits dying with low blood pressure after compression of both legs.

An inspection of Figures 11 and 12 which illustrate the course of blood urea determination in groups B, C, D (with varying extent and duration of crush) shows a similarity in behavior to that of hemoglobin values, except that the blood urea is less responsive to crushes of small extent.

**6 Other biochemical changes in the blood**  
**a Serum potassium** Rabbit blood is very susceptible to hemolysis; should this more than tinge the serum pink, the potassium content may become erroneously high. We found it necessary to centrifuge the blood before coagulation had occurred. A further source of error was that blood drawn from the heart immediately after killing the animal by a blow on the neck also gave erroneously high values. Failure to appreciate this point vitiated many early observations. After rejection of all estimations taken on blood at death and all specimens with traces of hemolysis, it was found that following crush the potassium content did not rise above normal

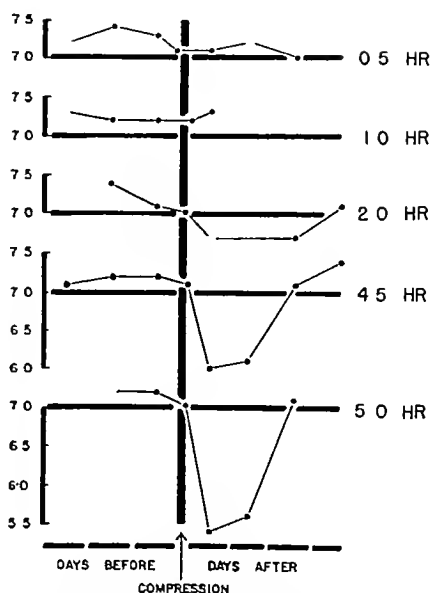


Fig 12 Change in urinary hydrogen ion concentration following compression for periods varying from 0.5 to 5 hours

(15 to 23 milligrams per cent, average of 32 values 19 milligrams per cent) in the majority of animals. One experiment only showed a rise, from 20 milligrams per cent before to 28 milligrams per cent at 48 hours, falling to 22 milligrams per cent at 120 hours. The 13 remaining experiments included 2 experiments in which both legs were crushed, with a calculated necrosis of 25 milliliters per kilogram, and one experiment in which only 2 turns were made, with a calculated necrosis of 3 milliliters per kilogram. The remainder followed the standard procedure. This may be compared with the potassium rise following simple ligation of both ureters (e.g., from 21 milligrams per cent before to 30 milligrams per cent on the second day).

**b Phosphate** This was not increased from the normal level of 2.5 to 6.1 milligrams per cent (average of 33 values 4.5 milligrams), in animals crushed by the standard procedure, or in animals in which both legs were crushed up to 25 milliliters per kilogram. The higher values within the normal range did not appear to be correlated with high blood urea rise or high potassium figures. For contrast, in rabbits with ligated ureters, the phosphate rose parallel with the urea and potassium

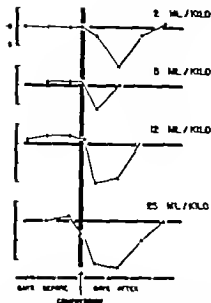


Fig. 3. Change in urinary hydrogen-ion concentration following compression of varying extent for the standard time.

(e.g. from a normal level of 4.6 milligrams per cent to 6.5 and 8.9 milligrams per cent on the 3d and 4th postoperative days respectively). This paralleled a urea rise to 430 milligrams per cent and a potassium rise to 30 milligrams per cent).

In this estimation again hemolysis must be avoided; specimens taken from the heart immediately after death may occasionally show abnormally high results, and all such estimations have therefore been discarded.

*c. Plasma protein.* From an average control figure of 6.5 grams per cent (33 normal values ranging from 5.8 to 8.0 grams) the total plasma protein concentration fell 5 to 10 per cent from the initial value, reaching a minimum between 3 and 4 hours after release in general therefore running inversely parallel to the hemoglobin concentration. If then returned to the precompression figure within 24 hours. (Characteristic examples are seen in Figs. 18, 19 and 20). This behavior is opposite to that of hemoglobin: the explanation we suggest is that the blood loses protein into the damaged area and gains water from the tissue spaces faster than the reserve protein can be mobilized.

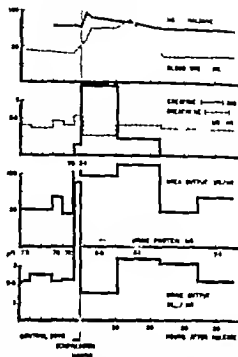


Fig. 4. Changes following the standardized compression (one leg, 8 hours for 46 hours). Note blood urea and hemoglobin rise, creatinuria, increased urea output, and acidity. No renal hypoperfusion.

*d. Carbon dioxide combining power.* From an average control figure of 43 milliliters per 100 cubic centimeters (17 normal values ranging from 34 to 57 milliliters per cent), the alkali reserve fell soon after release (2 to 4 hours) to 40 to 80 per cent of the control figure often returning to normal values within 24 hours (Fig. 19), sometimes remaining low for a longer period (Fig. 18).

*7. The urine a. Formed elements.* The first urine passed after release of the compression usually contained hyaline casts. These might be numerous; they gradually disappeared during the next few days and were replaced by a few granular casts. In the later specimens, sometimes granular casts containing small cuboidal epithelial cells were seen on occasion, these small cuboidal epithelial cells appeared free and were numerous. It is not thought that these came from the bladder. There were no red corpuscles and the benzidine test was negative.





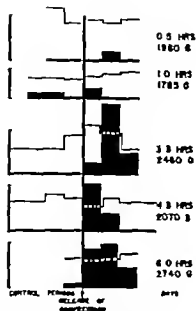


Fig. 7. Creatinine and creatinine output after release of compression for periods varying from 5 to 6 hours.

normal level of 7.0-7.2 to a minimum of 5.4. With the standard procedure the minimum lay between hydrogen ion concentration 5.4 and 6.0 the lowest value usually occurred between 5 and 20 hours after release. Neutrality was regained by 2-3 days after release, sometimes earlier (see Figs. 12 and 13).

**d Urinary urea and creatinine.** There was usually an increase in the output of urea following the crush, often to double the previous level (Fig. 14). The creatinine output remained much more constant, and therefore as can be seen in Figure 15 the urea-creatinine ratio in the urine rises. During this time the rabbit usually ingested a normal amount of food protein except sometimes during the first 24 hours. The conclusion to be drawn is that there was increased protein breakdown. Judged by excretion this was maximal on the first or second day. Several cases analyzed more closely showed an immediate increase in output of urea, before release, due to diuretics (Fig. 14). The urea-creatinine ratio stayed constant. Immediately after release (or before if leakage occurred as indicated by the appearance of creatinuria) the urea-creatinine ratio increased due to a rise in the total urea

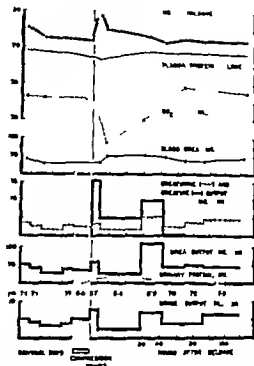


Fig. 8. Changes following the standardized compression (8 turns for 4-6 hours). Note the fall in carbon dioxide combining power within 4 hours of release.

output. This might remain up for a week. The extent and duration of the increased output of urea bore little if any quantitative relation to the extent of the damage (Table I). No evidence is presented on the source of this protein breakdown, whether local or general, but according to Cuthbertson both mechanisms are involved in similar experimental preparations.

**e Urinary creatine.** This appeared in the urine immediately after release (Fig. 16). As may be seen from Figure 17 the amount liberated was small below 2 to 3 hours compression while above this point no further significant increase was seen with increasing duration of compression. In a similar way no definite relation was seen between amount of tissue made necrotic and creatine set free.

**f Tissue fluid.** The edema fluid protein content at postmortem in 21 of the experiments varied between 2.4 grams and 4.8 grams per cent, with an average of 3.6 grams per

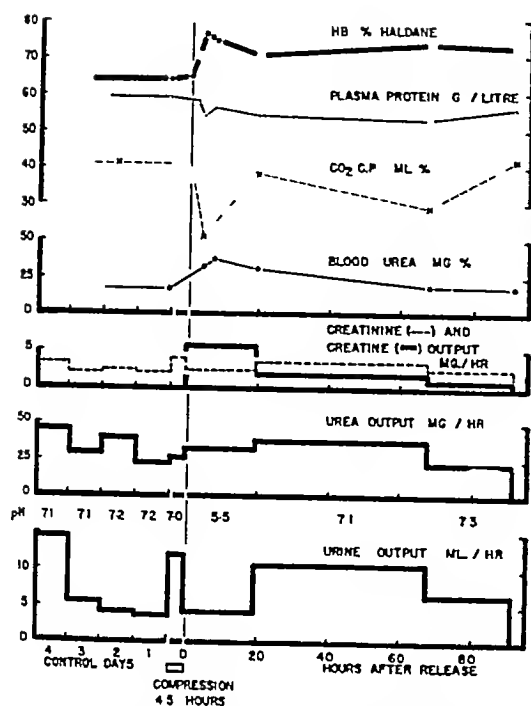


Fig 19 Changes following the standard compression (8 turns for 4.5 hours). Note the fall in plasma protein and the increased urine output on the second and third days

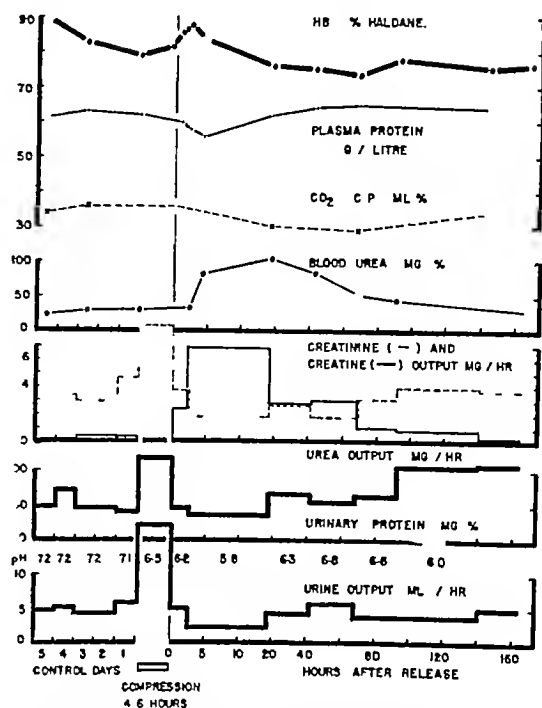


Fig 20 Changes following the standard compression (8 turns for 4.6 hours). Note the delayed increase in urea output

cent. Expressed as a percentage of the terminal plasma protein in 20 of these experiments, it ranged from 46 to 77 per cent with an average of 59 per cent of the plasma value.

The "thiocyanate space" which is a measure of the extracellular tissue fluid volume, showed some slight increase following release of the compression in a few preliminary experiments. The increase, however, was usually small (Fig 21) and could be accounted for by the volume of cellular material rendered permeable to thiocyanate by necrosis. This would mean that there was no cellular dehydration with that degree of damage. Equilibrium, which is reached between 30 and 60 minutes, following injection in the normal, required a longer period after following release of compression.

#### ANALYSIS OF STUDY

*The experimental lesion* The findings indicate that the experimental injury sets in motion two main processes (a) a loss of sub-

stances (fluid, protein and salt) from the bloodstream and from the body generally into the injured part, causing first, *local increase* in fluid, protein and salt, manifest as edema, and second, *general decrease* in fluid, protein and salt, manifest as hemoconcentration, fall in plasma protein and tissue dehydration.

(b) An accession of substances from the damaged area into the bloodstream (directly and via the lymphatics) and thence into the body generally and into the urine. Some of these substances seem to be of an acid nature, as manifest by the fall in carbon dioxide combining power of the plasma and the fall in urinary hydrogen-ion concentration it seems possible that one of these substances is lactic acid.

Another of the substances found in the urine which is derived from the damaged muscle is creatine. This occurs under any conditions in which muscle fibers undergo autolysis. Whether potassium, phosphorus, amino acids, or other easily stored products of cellular

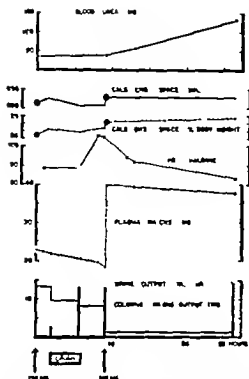


Fig. 1. Changes in thiocyanate distribution space (extracellular tissue fluid volume) following compression. Circles indicate observed values calculated by extrapolation following injection; dots indicate observed values calculated after subtraction of thiocyanate excreted in the urine. Note the very small rise (from 6.5 to 6.25 ml only) which is less even than the amount of cellular tissue rendered permeable to thiocyanate by necrosis (75% of 50 ml, the total volume of tissue compressed).

autolysis are also liberated has not yet been investigated. The potassium and phosphorus concentration in the blood serum do not rise beyond normal limits after release of the compression.

**Relation to human types of injury.** The secondary effects of the loss of fluid protein and salt into the damaged area classified under (a) e.g. hemoconcentration fall in blood volume vasoconstriction, and fall in blood pressure are described when seen in man as "shock." As we have recently learned however hemoconcentration in human "shock" is rare and occurs chiefly following burns and crushing injury (Grant and Reeve 1941). It is due to loss of plasma into the damaged area. This method, therefore, seems suitable for re-

producing in the rabbit these particular aspects of burns or crushing injury known loosely as shock.

Furthermore the effects classified under (b) (due to substances leaving the damaged area) are also seen in man following crushing injury. The urine is very acid, the plasma carbon dioxide combining power is diminished and creatine occurs in the urine. The resemblance of the crush syndrome in man to that produced in the rabbit by this method is thus very close. In two particulars, however the parallel fails. The injury in man is accompanied by loss of myohemoglobin from the damaged muscle which comes to resemble fish flesh and by its excretion in the urine. This may be followed in a few days by signs of renal failure (oliguria, increase of blood urea, phosphate creatinuria, and decrease in carbon dioxide combining power). In two-thirds of the reported cases, death has occurred (Bywaters, 1942). The failure to produce myohemoglobinuria and the inability to produce a renal lesion severe enough to cause death, or indeed any serious degree of uremia, are we think, associated both with each other and with the absence of myohemoglobin in those muscles of the rabbit which we compress. This has led us to another line of inquiry which will form the subject matter of another paper. However we think it is of interest that we should be able to reproduce the shock aspect of crushing injury uncomplicated by any marked degree of renal damage.

**Excretory function.** Excretory impairment is manifest in the rabbit in the first 24 hours after release as judged by the small rise in blood urea and the decrease in urine volume and urea and creatinine output sometimes seen. In most of the experiments, however the urea output was increased over that of the control period. This we thought was due to increased protein breakdown which can be considered as partly responsible for the rise in blood level. The concentration of urea in the urine was fairly high during the oliguric period, often exceeding 3 grams per 100 milliliters and we attribute this temporary failure of excretion therefore not to renal impairment but to increased formation of excretable substances and to the reduced circulating

blood volume. It seems possible that if the blood volume be diminished due to loss of plasma, the venous return will be less, the cardiac output less, and the renal blood flow may therefore be diminished.

Some slight renal damage, however, does occur, if proteinuria and cylindruria be taken as sufficient evidence. However, both these occurrences are seen in man without evidence of a renal lesion (postural or orthostatic albuminuria and the albuminuria and casts seen after exercise), their sudden appearance in the rabbit following release of compression might indicate an increased permeability of the glomerular tuft or some lesion of the tubules. There is no evidence of an increase in capillary permeability other than in the injured area, as judged by trypan blue coloration, but it is possible that the glomerular tufts are particularly sensitive. An alternate possibility suggested by Eggleton (personal communication) is the protein in the urine might be the first stage breakdown of muscle protein, molecules small enough to be filtered by undamaged glomeruli. This has not yet been investigated. Summarizing, renal damage, if it exists at all, is very slight and of short duration. In this, the impairment of excretory function is unlike that seen following crushing injury in man, but resembles that seen following other experimental injuries designed to induce a 'shock'-like condition, certain relevant types of which will be considered next.

*Other experimental lesions.* Many able reviews of the experimental methods used to produce 'shock'-like conditions have recently appeared (Harkins, Moon, Blalock) and it is only necessary here, therefore, to mention those types of injury whose effects resemble those we have produced in the rabbit and those seen in the crush syndrome in man. Those effects seen in crushing injury in man and in the rabbit, classified as due to substances leaving the blood stream, are common to the injury of burns, to that following the injection of concentrated salt or glucose solutions underneath the skin, intraperitoneally, with or without subsequent removal of the effusion, or intravenously with salt and water loss in the urine, following necrosis of bowel

or intraperitoneal implantation of minced muscle. Minor but important differences distinguish the results of these varying procedures, these appear to be due chiefly to such variables as the reavailability of the substances so lost, the rate of loss, and the total supply of sodium chloride or water available to the body, and the presence or absence of secondary infection (e.g., anaerobes in the peritoneum). When excretory function has been investigated, it appears in most of these experimental lesions to be impaired only temporarily, and is demonstrated either by such phenomena as albuminuria and cylindruria, or, if a severe strain is placed on the kidneys as, for instance, in Black's (1940) experiments with an increased urea load, by a rise in blood urea. In common with the conditions mentioned, excretory impairment in this experimental crushing injury appears to be temporary, functional rather than structural in nature, and dependent on such "extra-renal" causal factors as (1) increased urea formation, (shown by the increased urea output with a normal creatinine output), (2) tissue dehydration (shown by general dryness and by the accumulation of fluid locally without gain in weight of the animals, together with a fall in serum protein and rise in hemoglobin concentration), (3) fall in filtration pressure in some cases, due to fall of blood pressure, and (4) perhaps to decreased renal flow (as a possible result of oligemia) and other factors yet unknown.

The effects in the rabbit corresponding to those in man which were here classified as due to substances leaving the damaged area, e.g., the acidosis and the creatinuria, have been reproduced by methods more closely resembling our own.

Andrews (1927) in the course of experiments designed to study the effect of acidosis on colloid structure and water metabolism, observed that an acidosis developed in dogs whose paws had been tied too tightly to the operating table, as soon as the ligature was released. He was unable to identify the acid, but thought it might be lactic acid. Apparently all his animals received large quantities of 5 per cent sodium chloride intravenously, and "nearly half" showed a picture like that

of uremic coma. Unfortunately the description of methods and results is too inadequate to draw any useful conclusions from them. A similar procedure was adopted by Wilson and Roome in 1936. They studied with great care a series of 19 dogs in which one hind limb had been ligated under sodium barbital anesthesia by two turns of rubber tubing wound round the legs at the level of the hip joint. A metal skewer was used to keep the tourniquet at this level. Two animals constricted for less than 3 hours recovered as did 4 of the remaining 17 constricted for longer periods. Radio-opaque injection showed no arterial spasm; death could be prevented by amputation and transfusion but by neither alone. Observations on the presence of clostridia in the muscle were made but no deductions were possible as to the rôle they played as they occurred also in the control limb. However gas bubbles and crepitations were noticed in 3 animals. It seems that the lesion produced by Wilson and Roome was very similar to our own. It was complicated however by a prolonged barbital anesthesia, with inanition (which by itself killed 1 of 6 controls) and by the presence of an open wound and a Welch like infection. They concluded that the amount of fluid lost into the ligated limb was adequate to cause death, in conjunction with the prolonged anesthesia and inanition. A somewhat similar study in 60 three month old rats was undertaken by Salzburg and Kabat (1941). They were interested mainly in the difference in survival (following ischemia) of normal and neoplastic tissue; no biochemical data are given. They found that if the circulation to the hind limb was cut off by rubber ligature gangrene ensued. If however ischemia was produced by an inflatable rubber cuff at a temperature of 82 degrees F. the rats all survived a seven hour stasis but none survived ischemia maintained for 8 hours. An inflammatory edema and some atrophy was noticed in the surviving rats. Allen's (1938) work on the survival of ischemic muscle at various temperatures is also relevant. He found that tissue survived much longer periods of ischemia if cooled; the critical ischemic time was decreased if the temperature was raised. More recently

Cuthbertson (1942) having followed up a study in man by one of metabolic changes following fractures in rats has laid considerable emphasis on the general increase in metabolism which accompanies the local metabolism of trauma; he suggests that the local tissue loss is inadequate to account fully for the increased nitrogen, potassium and phosphate wastage. This is a possibility which we have not yet investigated.

It would be of very great interest to investigate the effects of a similar injury in an animal such as the dog whose muscles contain myohemoglobin. Some work of this nature is already in progress (Winton and Egginton, personal communication); renal damage and myohemoglobinuria has been produced.

#### CONCLUSIONS

Few conclusions can be drawn except that this method of injury produced the results here described; that they are similar to the effects of crushing injury in man, except that myohemoglobinuria and renal failure do not occur. Other conclusions relevant to the crush syndrome in man which may be useful in prognosis and the critical assessment of treatment, are:

1. There appears to be a minimum time below which ischemia does not produce necrosis; above this, prolongation of compression does not increase the severity of the lesion.

2. The severity of the lesion—that is the extent of muscle that has been damaged—is indicated within certain limits by the height and duration of the rise in blood urea and hemoglobin and the fall in urinary hydrogen ion concentration and plasma carbon dioxide combining power.

#### SUMMARY

A method of producing graded injury in the rabbit is described. It consists of winding a rubber band round the leg so as to produce an ischemia which is maintained for a period of between 4 and 5 hours. The resulting course is characterized by hemoconcentration and loss of plasma into the injured area which becomes swollen and doughy. Anotemia occurs, which is thought to be due in part to the depressed circulation but mostly to increased

issue breakdown. Other manifestations of the latter are creatinuria and a depression of the carbon dioxide combining power of the plasma, associated with an increased urinary acidity. No impairment of renal functional ability occurs (as measured by the power to concentrate urea) that is grossly obvious, although a few hyaline and granular casts appear, and are sometimes accompanied by a trace of proteinuria. No myohemoglobinuria occurs, this is not surprising, as the compressed muscles contain practically none of this pigment. The condition differs from the human condition of "crush syndrome" only in these two respects (absence of renal failure and absence of myohemoglobinuria), and as there is ample anatomical reason in the rabbit for myohemoglobinuria to be absent, it seems possible that these two negative "occurrences" may be causally related to each other.

**ANALYSIS.** Since this paper was prepared for publication an article by Duncan and Blalock (Ann Surg 1942 115, 684) has appeared that produced a similar lesion in dogs by compression between two rigid boards. The animals were not allowed to survive for long enough to investigate renal changes. "Shock" could be partially prevented by the application of a pneumatic sleeve at a pressure of 40 millimeters mercury. As no figure is given of the protein nitrogen rise in the treated animals it is impossible on these data to make deductions as to the effect on renal function. It may be that the shock aspect of crushing injury could be treated more cheaply by bandages

or cuffs (Patev and Robertson Brit M J 1942, 2, 53) than by plasma infusion, but there is as yet no evidence whether these procedures would increase or decrease the mortality of this injury which is always due to renal dysfunction not shock except in neglected patients.

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## ROUTINE ABDOMINAL PANHYSTERECTOMY

### As Prophylaxis Against Cancer of Cervical Stump

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THE importance of a residual cervical stump following supravaginal hysterectomy as a possible nidus for subsequent cancer development has given rise to varying points of view and consequently to different practices.

The major issue seems to be whether when abdominal hysterectomy is done for benign disease of the uterus or uterus and adnexa total hysterectomy should be employed as an inflexible routine in order to forestall by one procedure all danger of future malignant change which presumably exists as long as there is the slightest cervical residuum.

Other issues which have been raised, such as removal of a symptom producing cervix as against later treatment of such a cervix if left as the result of a supracervical hysterectomy, the question of vaginal shortening alteration in vaginal secretion etc. are purposely omitted.

One cannot help but conclude from the recurring discussions and a perusal of the current literature that there is still confusion and misinterpretation of statistics by some as to this problem.

It becomes essential, therefore from the standpoint of statistics if one desires to compare cervical cancer and uterine myomas, for example to have clearly in mind whether one is comparing the incidence of cancer with myoma, the incidence of myoma with cancer or the simultaneous occurrence of myoma and cancer. Likewise it is one thing to speak of the incidence of cancer of the cervical stump in relation to cervical cancer and quite another to speak of the incidence of cervical cancer among cervixes left as residua following supravaginal hysterectomy. Also, one is confronted by the problem when to classify a cancer occurring in a residual cervical stump as one that was in existence at the time of the original supravaginal hysterectomy or one that developed in a previously noncancerous cervical stump, i.e. *de novo* "cervical stump cancer." Therefore the ratio of cervical stump cancer to cervical cancer in general is not particularly pertinent to this specific problem unless one knows the ratio of cervical

stump cancer to all supravaginal hysterectomies. The latter again may be misleading if one does not know the incidence of unsuspected cervical cancer present at the time of the supravaginal hysterectomy. One sees nevertheless the incidence of cervical stump cancer among cervical cancers in general interchangeably quoted as representing the incidence of cancer in cervixes remaining after subtotal hysterectomy.

#### RELATIONSHIP OF CERVICAL STUMP CANCER TO CERVICAL CANCER

Table I reveals the fluctuations that occur in some of the reports that deal with the incidence of cancer of the stump in relation to cervical cancer in general. In addition, we should mention the experience of Petkau and Amreich at the first University Frauenklinik, Vienna. They encountered 13 cancers of the cervical stump during a 16 year period comprising probably less than 2 per cent of the cervical cancers observed during that time.

From the foregoing it may be assumed that cancer occurring in the cervical stump following supravaginal hysterectomy comprises from 2 to 4 per cent of cervical carcinoma. There are a few statistics that give both higher and lower values than those here given. It is a problem to know how to evaluate them when one considers as (1) be shown how frequently supravaginal hysterectomy has been done in the presence of unsuspected cervical cancer in this special group of patients.

The difficulty of evaluating some of the statistics relating to this matter when presented in tabulation can be appreciated when it is recognized that in numerous instances they are not comparable. Some authors in reporting the ratio of cervical stump cancer to cervical cancer include all stump cancers irrespective of how soon they manifest themselves after supravaginal hysterectomy. Others regard a year postoperative period of freedom from "stump cancer" as evidence that the cancer did not exist at time of original operation. Others believe that longer periods should be used as criteria to exclude the presence of unsuspected cervical cancer at time of supravaginal hysterectomy. Nevertheless, one generally sees figures—arrived at differently—indiscriminately compared. For example

From the Department of Surgery, University of Oregon Medical School. Read at meeting of the Johns Hopkins Medical and Surgical Association, Baltimore, Maryland, February 1932.





these and 201 represented inflammatory disease without myomatous change. Each group revealed 4 instances of cancer in the residual cervical stump.

A compilation of the acceptable world literature by Faehndrich gives the incidence of cancer of the cervical stump following supracervical hysterectomy for benign disease as 0.39 per cent, while Albrecht puts the incidence at 0.34 per cent stating that he had encountered none in his material at Munich. Franz, according to Albrecht, traced 635 patients, who had had previous supravaginal hysterectomies, for a period of 18 years and encountered no cancer in the residual cervix. However the shortcomings of all these compilations should be remembered.

The observation that supracervical hysterectomy may be done in the presence of unsuspected cervical cancer raises the question when a cervical stump cancer should be considered as having developed in a previously noncancerous cervix. Some writers, as previously noted, believe that cancer developing one year after operation should be considered satisfactory evidence that no cancer existed in the cervix at the time of the original supracervical hysterectomy. At the other extreme are those who believe that cancer developing in the residual cervical stump within 3 years after the original operation should be considered as probably existent at the time of the first operation. At first sight the latter position may appear extreme and rigid. Granting that this concept is not always correct when applied to individual incidents, there is however much to support it.

A study of the peculiarly spaced time intervals that mark the manifestations of this complication, as noted by Herold, quickly arouses one's appreciation of this and suggests the pitfalls inherent in many statistics. The great bulk of cervical stump cancers may be divided into two major groups from the standpoint of the time of their occurrence after supravaginal hysterectomy (Fig. 1). One large group occurs during the first 3 years after operation and the other large group occurs after the 5th year following operation. Between the two there is a precipitate decline in the incidence of stump cancer. The regularity with which this occurs largely removes the observation from suspicion of mere coincidence or statistical error and, we believe, offers excellent reason for considering the great bulk of cervical stump cancers that manifest themselves during first 3 postoperative years as probably existent and unrecognized at time of original operation. A broad, rigid application of such a rule should result, in some inaccuracy. However when applied to statistics it should prove an excellent, fair and salutary yardstick.

Some of the statistics we have quoted earlier reveal that about 40 per cent or more of cancers of the cervical stump occur well within 3 years after operation. Confirmatory of this is a collective review by Faehndrich, of 599 instances of cervical stump cancer in which the time of occurrence was noted as follows: 58, or 10.4 per cent, developed during the 1st year after operation; 81 or 33.8 per cent, developed between the 1st and 3rd year after operation; 42 or 14 per cent, developed between the 3rd and 5th year after operation; 13, or 43.8 per cent developed 5 or more years after operation. Of this group 173 cancer developed from 10 to 30 years after supracervical hysterectomy.

#### TOTAL VERSUS SUBTOTAL HYSTERECTOMY

In view of the fact that cancer may develop in the residual cervix after supravaginal hysterectomy for benign uterine disease, it has been proposed by some observers that performance of total hysterectomy as an inflexible routine would eliminate this complication. These observers also state that in competent hands the mortality from total hysterectomy is little if any more than that following subtotal hysterectomy and they advocate therefore without reservation, the total operation when hysterectomy is to be done.

On the other hand there are numerous opponents to the proposal that total hysterectomy be performed in every instance in which hysterectomy is to be done. This does not mean that panhysterectomy should never be employed for benign disease but that its use should be a matter of individualization and restricted to those instances in which there is an obviously pathological cervix, and the operation can be done without undue hazard. The basis for objection to total hysterectomy as a routine is that rigid adherence to the procedure leads to an increased operative mortality and morbidity; the operation is ordinarily inadequate to cure patients who have an established but unsuspected cervical cancer and the hazard of subsequent cancerous change in previously noncancerous cervix is not as great as the increased mortality inherent in the total operation. Finally the objection has been raised that the total operation is no guarantee that cancer may not develop later in the vaginal vault.

The relative mortality of these two operative procedures is difficult to compare. It is obvious that when exposure is difficult or the patient is or has become poor surgical risk because of hemorrhage or some other acute contingency the supravaginal operation is the only procedure possible or permissible. Staunch advocates of the routine use



TABLE II.—COMPARISON OF MORTALITY RATES OF TOTAL AND SUPRAVAGINAL HYSTERECTOMY

Author	T	Number of operations (all abdominal)	Mortality per cent.	
			Total hysterectomy	Supravaginal hysterectomy
Amreich, I	1917	For myomas		
Dawson, W. C.	1914	100		0
		41		0
Dawson	1914	30		0
		90		0
Duportail, S. M. and Zachman, R. (Peter Bent Brigham Hospital)	1910	14		
		10		0
Fendrick, J.	1914	113 uncomplicated myomas		0
		707		
		all benign diseases		0
Frank, K. (quoted by Wadley)	1910	611		0
Fulerton, W. D. and	1910	101		0
Fathauer, R. L.		1071		
Kelly-Cullen (Gynecological hysteromyomatous cases of all types) (The Johns Hopkins Hospital)	1910	(years 1897-1906)		+
		(years 1907-1908)		
Kronig	1914	18		0
Mason, J.	1910	740		
		779		
Moss, J. A. (Massachusetts General Hospital)	1914	777		
		10		
Muller, H. E. and	1911	13		
Proctor, O.		17		10
Pearce, R. L. (New Hospital for Women, Brookline, Mass.)	1914	7000		
Rand, C. D. and	1911	1009		0+
Reid, A. C.		17		
Ramsey, J. C. and	1911	770		
Waters, T. B.		0		
Schell, R. S. and	1911	111		
MacC, H. C.		11		
Talbot, R. W. (Personal communication) (All types of benign disease) (The Johns Hopkins Hospital)	1911	60		

\*This figure generally quoted as 4.4" but this we cannot verify

TABLE II.—Continued

Author	T	Number of operations (all abdominal)	Total by any means	Mortality per cent.
Wadley, L. (Report covers 112 total hysterectomies but does not give mortality figures for all of these)	1914	130 uncomplicated myomatous cases		
Wadley (quoted by Wadley)				
W. W.	1910	660		
	1910	111		0
Albrecht, H. (indicated carcinoma)	1910	117		
Dawson (Quadruple Enucleation collected statistics)	1910	100		0

The fact that cancer of the vaginal vault, as reported by Meigs, Tyler and others, occurs occasionally after panhysterectomy has been used as an argument that panhysterectomy is not the panacea as claimed by some, against future development of cancer at the former site of cervix.

This argument possesses undoubted value but it is not as conclusive as it sounds. When one reflects that cancer of the vagina may occur in the presence or absence of the cervix uteri. The 13 cases ascribed to Tyler represent instances reported in the French literature, and essential details are lacking. Also when cancer occurs in the vault after a previous panhysterectomy one can not be certain, unless one has had an opportunity to study carefully the original operative specimen, that the entire cervix had been removed, or that it may not have harbored an unrecognized cancer.

The value of total hysterectomy for cancer prophylaxis is granted. However as we view the situation, the important consideration in deciding to do an abdominal panhysterectomy is not the presence of a myomatous uterus, or the obvious desirability of removing simultaneously a symptom producing cervix, but the ability to do the operation without additional risk to the patient. The presence of benign disease of the cervix and the fear of subsequent cancerous change, in, we believe, no special indication for panhysterectomy if this procedure entails an increased operative hazard. The so called "angry red appearance" of a bleeding circumstantial vermilion zone offers real fuel to the suspicion that the fire of cancer is

near at hand. The statement is therefore frequently encountered that an "eroded" inflamed cervix offers special danger of subsequent development of cancer. There is, however, little if any factual information to support this constantly repeated assumption. All of the truly early *bona fide* cancers we have seen so far have occurred on relatively normal appearing cervixes. It is, I believe, extremely doubtful that one can foretell from the appearance of a cervix involved in a benign inflammatory process whether it is more likely to develop cancer than a normal appearing cervix. Nulliparity is no guarantee against subsequent cancer development. Therefore, the admonition that when hysterectomy is indicated for benign uterine disease, a diseased cervix is a strict indication for panhysterectomy, because it is particularly prone to develop cancer if left *in situ*, becomes largely a matter of individual opinion, unsupported, as far as we can ascertain at this time, by acceptable proof.

#### SUMMARY

The statistical data on which are based some of the arguments regarding this controversial subject, are in some respects unsatisfactory and inconclusive. It appears, however, that the incidence of cancer in the residual cervix after supravaginal hysterectomy is less than 1 per cent. Total hysterectomy, except when used as an elective procedure by well qualified individuals has a mortality rate definitely in excess of the supravaginal operation. The difference in mortality between the two operative procedures is evidently in excess of the incidence of *bona fide* cancer which may develop in the residual cervix after supravaginal hysterectomy. There is good reason, therefore, to doubt the wisdom or factual basis for advocating panhysterectomy as a fixed routine when hysterectomy is to be done for benign uterine disease in order to avoid the possibility of subsequent cervical cancer.

There can be little question of the desirability of panhysterectomy as prophylaxis against subsequent cancerous change in a residual cervical stump when the operation is used as an elective procedure without additional hazard to the patient.

There is good reason to believe that as a general rule cancer manifesting itself in a residual cervix within 3 years after supravaginal hysterectomy for benign disease was present but unsuspected at the time of the original operation.

The admonition that benign inflammatory disease of the cervix offers particular predisposition to later cancerous change is open to question.

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# REPAIR OF THE INCONTINENT SPHINCTER AN

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**I**n previous papers some of the general facts and specific problems associated with injuries to the sphincter and muscle and its surgical repair have been discussed (1-3). Particular attention was called to material deficiencies of what had been commonly regarded as a satisfactory operation for the relief of incontinence and a report was given of our experience with an operation which gave promise of certain definite advantages, amply established in our hands. Since that time further personal experience with this latter operation together with reports from other surgeons has but strengthened our confidence in it. We therefore turn now to a different phase of the problem.

First, however, in evaluating the importance of this general topic let us emphasize that much surgery of greater technical magnitude may actually represent far less in ultimate import. For let it not be lost sight of that a successful operation in this field does not just restore the function of a small muscle. In the truest sense it rehabilitates an otherwise useless, ruined life to grateful existence. Only one who has dealt with these patients appreciates the full meaning of this truth.

Intelligent discussion of reparative surgery of the incontinent sphincter must be based on the recognition of three rather clear cut groups of cases. The failure to distinguish between such divisions as presenting quite different problems has heretofore rather clouded the issue. For example one bears comparative approbation of different operations when actually their design served totally different purposes. For more or less consideration therefore we suggest a strict anatomical grouping on the basis of relative amounts of intact functioning muscle remaining and available to the surgeon as a foundation for repair.

The great majority of cases even with complete incontinence involve comparatively small segmental deficiencies of the muscle. This is readily understood when one reviews the causes involved (4). It is this major class and only this class for which the classic plastic repair is dubiously useful and it is this class which we discussed in our first paper and for which we proposed the simpler and more satisfactory operation therein described.

The other anatomical extreme fortunately involves numerically the fewest cases and is comprised of those instances in which the muscle is either congenitally absent or totally destroyed for all practical purposes by exceptional circumstances. In this relatively small class there is an entirely different problem of constructing a complete new sphincter from totally extraneous voluntary muscle tissue, usually the pectoral.

The middle ground is comprised of those cases in which a large segment, say up to approximately a half of the sphincter has been destroyed. It would seem hopeless on the one hand to make reparative use of any smaller amount than this of remaining muscle and yet this much muscle or any more seemed too much to just cast aside. On the other hand, from the surgical standpoint there is the distinguishing problem of excessive post-operative tension were the usual plastic repair attempted. While our own reefing operation, so successful in the first group, is obviously inapplicable when a large segment of muscle has been destroyed because instead of converting this muscle into a functioning circle of smaller circumference it would tend simply to flatten out the effective portion remaining. Heretofore it has been the characteristic history of cases in this intermediate group to be subjected to one or more totally unsuccessful attempts at suturing the dissected ends of remaining muscle and then to be relegated to candidacy for the complicated operations of foreign muscle transplantation which constitute the only hope of the extreme group mentioned. We therefore sought to devise some satisfactory technique to take advantage of an appreciable amount of good muscle tissue and rescue such cases from the class of total absence. This is the topic of the present paper.

Considerable difficulty from several sources might be surmised in differentiating clinically the three groups and accurately evaluating the varying amount of functioning muscle remaining. In the first place the surgeon who is finally called upon to repair the damage is not usually the one who has followed the case to that point and they had the benefit to orientation of participating in previous dissections. But even more importance attaches to the fact that the degrees of physiological and anatomical damage have little parallel relationship while incontinence of gas alone can only



Fig 1



Fig 2



Fig 3

Fig 1 Photograph of case reported, illustrative of incontinent anus with extensive destruction of the sphincter muscle and with scarring of previous unsuccessful attempts at repair. In this case only the anterior half of the sphincter remains as indicated by overlying puckered skin. Anal opening widely patent.

Fig 2 Photograph of same case 2 weeks after first stage operation, with incision completed for second stage opera-

tion. Anal opening has been considerably diminished by the transplantation of muscle bearing flaps, with the sphincter now surrounding approximately  $\frac{3}{4}$  of the anal circumference.

Fig 3 Photograph taken 10 days following second stage operation. One stay suture only remains. Anal opening is completely closed and the sphincter now completely encircles it.

occur from minor injury, yet on the other hand complete incontinence may supervene from very little more, or even the same amount elsewhere on the circumference. All three grades of incontinence (to passage of gas, liquid, and solid stool) may occur in our first anatomical group. As a matter of fact, though, the determination of anatomical injury is usually rather easy, because the skin overlying intact muscle is thrown into folds by contraction of the latter, while the skin overlying any defect is not so affected and hence tends to be smoothed out. Figure 1 illustrates this quite dependable finding. In cases of relatively minor injury a scarred and sometimes slightly depressed notch marks the area of previous injury and separation of the muscle ends.

In devising a possible new or improved type of operation for the group under discussion we naturally turned first to an analysis of the causes of failure with the usual suture of the muscle ends freed by dissection. With such a large defect to be bridged the outstanding shortcoming was unquestionably the extreme tension to which the sutured muscle ends were necessarily subjected. This hazard is precarious enough when only small deficiencies exist as indicated by our previously reported statistics. In the case herewith reported, exemplifying the group with much more serious defect, half of the muscle circumference had been

destroyed. Under such circumstances, and in accordance with the physical laws of elasticity, even if the whole remaining half could be completely mobilized and utilized the tension would be enormously increased. Considerations of tissue viability, which limits the amounts of muscle tissue which can be safely freed by dissection further restrict the potentialities.

Again, dissecting out the frayed muscle ends is in itself likely to be a difficult and protracted procedure even to one familiar with the regional anatomy, for the ends of the mutilated muscle are lost in a maze of dense scar. Furthermore, and at best, an appreciable amount of probably functioning tissue is sacrificed in reaching undamaged fibers in which clear-cut delineation of muscle belly is possible. Hence in this group in which the amount of remaining muscle is already of critical concern, this stage, difficult enough in cases of minor damage, looms as an even greater obstacle in the problem of bridging large defects. It must be admitted also that muscle tissue does not lend itself to suture under tension, being particularly susceptible to tearing when the sutures pull in the direction of the fibers, as here. And the vigorous trauma of protracted dissection certainly adds nothing to their strength.

A further obstacle interposed is that of inevitable wound infection with varying degree of



Fig. 4. First stage of operation, showing lines of incisions, commenced on left. This gives tongue-shaped flap of muscle bearing tissue on each side. With the tip of the flap to be transplanted and fixed at A. It is important to pattern the incision and to carry it deep enough to be certain of mobilizing muscle. We did not undermine flaps but this feature could be considered with propriety.



Fig. 5. Deep buried suture of flaps as shown. In fact, has approximated points 1 and 4 of Figure 4. (We tied down every foot in order as shown, and cut short—just as gut suture.) One stay suture has been tied—this is not the true suture shown in first, 1, others, 2, 3, have been placed. These are carried deep to operate, and 1, considerations of infection. Penetrating suture is shown started around operative field, though actually this was carried out until completion of both sides.

subsequent disruption. This is of course not unique to this group and we mentioned it in our previous consideration of minor injuries. But with increase of tension this factor assumes increased significance. Fundamentally any suture of an anal wound is a compromise with ideal proctological practice. Our efforts in combating infection represent nothing new but simply a combination of promising suggestions.

All factors considered it is little wonder that this operation gave little or no chance of success in connection with more serious injuries and extended defects.

We therefore planned and herewith report procedure to obviate or minimize these shortcomings. And for it we suggest the following advantages:

By a *two stage operation* involving *gradual transplantation* of the muscle ends in *steps* post-operative wound tension is reduced to proportions compatible with reasonable chance of success. Indeed through the use of our operation tension is entirely under control of the operator and could even be reduced almost *ad libitum* by additional operative stages. We emphasize that such control in itself may mark the whole difference between success and failure in the rehabilitation of the patient. In addition, and as a more minor expedient, a temporary purse string of tension suture was introduced immediately after operation at each stage completely to surround the operative site for the same purpose, controlling tension.

2. Instead of dissecting out and suturing the muscle ends themselves, we utilized as a second major principle almost instantaneously shaped and transplanted flaps of *muscle bearing tissue*. This provision in itself marks a radical departure in concept and procedure. We reasoned that material contribution would thereby be simultaneously made not only to tremendous simplification of the operation but also to strength of the suture line and to preservation of every fiber of remaining muscle. Such additional strength would be derived from two sources, viz. availability of tissue for suture better suited to withstand tension, and increased amount of such tissue available for suturing in distinction to the more limited muscle belly.

We could not see anything to be lost from a theoretical standpoint. For muscle has to be surrounded ultimately by other tissue either new or old and it is a rather universal law that other things equal, living cells lose rather than gain by transplantation to new soil. And here under the old regimen, any subsequent new soil would be preponderantly scar tissue anyway—the same kind of tissue removed to such arduous pains. Of importance also is the fact that

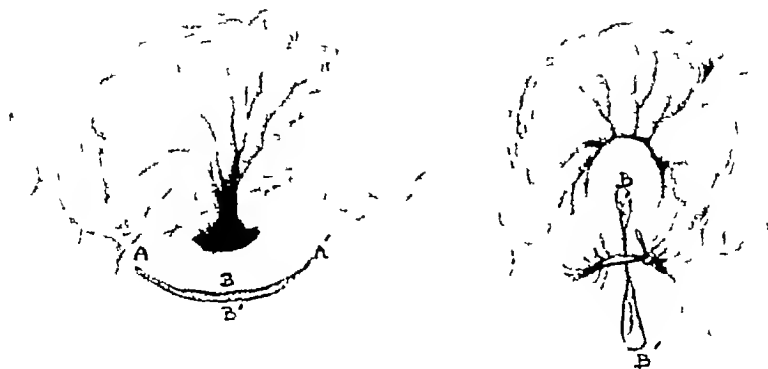


Fig 6 Second stage of operation 1. Incision commenced, again to be carried to greatest depth of sphincter muscle b Points A and B have been approximated by deep wire suture as shown in Figure 5 inset and one stay suture has also been tied—and too tightly as shown here. Notice how this type of operation closes anal opening without leaving a crevice wound directly contaminable from inside of anus. Removal of a “piece of pie” shaped segment, on the other hand, could accomplish the same approximation of the muscle ends but would leave a wound the depths of which would be in direct communication with the anal canal, gross contamination would in such case inevitably result either in breaking down of the wound or if the latter healed in a fistulous tract. This simple second stage procedure here illustrated might of itself supplant admirably the commonly used and more formidable plastic procedure (2) for minor deficiencies.

with our operation there is involved no sacrifice of functioning muscle tissue such as is inevitable in dissecting out the frayed ends of the sphincter.

While this transplantation of a muscle bearing flap was designed for the operation under discussion we see no reason why it is not applicable to great advantage in connection with the usual plastic repair of minor injuries. Or again it might be used for additive effect when our reefing operation fails to give complete satisfaction, or when inapplicable.

3 The operation devised is extremely simple. We early resolved that simplicity was so essential from every standpoint that we would discard anything of other attribute. But our success exceeded all we dared hope and we now are able to substitute a simple operation involving the work of actually but a few minutes for a long tedious undertaking, and with not only equal but far surpassing effectiveness. There are no superficial flaps to be raised for purposes of exposure, then to be closed, and the laborious and precarious dissection of muscle ends frayed and scattered in scar tissue is eliminated in even semblance. Such simplicity contributes directly in obvious manner and also indirectly in intangible but important respects such as diminishing trauma and the incidence and devastation of infection.

4 The incidence and effects of infection were opposed by the use of single buried stay sutures of alloy steel wire at critical points, the introduction of a sulfonamide drug directly into the wound, and the exclusive use of circumferential incisions which prevent direct leakage into the wound after operation from within the anal canal, these in addition to well recognized preoperative and post-operative precautions. We have also mentioned the elimination of inordinate operative trauma as a contributing factor.

The case reported herewith as illustrative of our technique is valuable to our purpose because it is tragically typical in deplorable history and distressing surgical sequence. But most important it served as a rather critical control in evaluating the merits of our procedure because the patient had been previously subjected with total failure to repeated reparative operations which sought to make use of the sphincter residuum, and to transplantation operations which attempted employment of extraneous muscle. These operations had been performed by capable proctologists in whose competence we have confidence. And while no one can say that it is either warranted or unwarranted to assume that the utmost possibilities inherent in these operations had been exhausted, it is obvious that they had had fair and repeated



trial by skills available to comparatively few patients. In contrast, our own result accomplished after all else had failed, was eminently satisfactory to the patient, and, by virtue of an operation readily available in performance to far larger body of surgeons, a correspondingly widened patient group could be benefited. Furthermore it is pointed out that every attempt at repair of these cases makes succeeding attempts both more difficult and precarious. This should mean even more hopeful anticipation should our suggestions be carried out for there would be the added benefit of primary attempt at restoration.

The patient whose condition is shown in the accompanying photographs gave the usual history of having been subjected over a period of years to numerous operations for a fistula-in-ano. The kindest thing one may say of the result is that it represents the fruit of some surgeon's or surgeons' total incompetence in this field. It left the patient so completely incontinent that with a desire for defecation he could not reach an adjoining bath room in time. And with all this the fistula was still uncured! With the hopelessness and despair of years he had become a derelict, utterly useless to society and devoid of any semblance of self respect or interest.

He first entered the proctological service of the Los Angeles County Hospital in 1935 at which time the fistula was easily eradicated. During the succeeding several years repeated attempts were made to improve his condition of complete incontinence. Both reparative and transplantation procedures were attempted with no improvement whatsoever.

The patient, as first admitted to my service in November 1937 (Figure 1 is photograph taken at this time and shows the abject pathos and opening. Palpation revealed the power of voluntary contraction but without appreciable effect in closing the sphincter. At this time performed the first stage of the operation. Incisions were made on both sides of the anus, being carried to the level of the depth of the sphincter muscle. Attempts to incise and undermine the muscle bearing flaps and to close what remained were removed. The opposing ends of the incisions were simply drawn together held first by single deeply

buried suture of alloy wire. Then the muscle bearing flaps were transplanted to its new location. The resulting exposed edges on either side of the flaps were fitted together and held loosely with interrupted tension suture layered deeply to the wounds in order. After completion of both sides parastitching of tension suture was introduced surrounding the hole anus and pulled and tied tightly thereby removing the last vestige of tension on the wounds. Postoperative care followed all recognized lines.

Figure 2 is photograph of the result two weeks after the first stage. The patient could now inhibit bowel movement for 40 minutes after the urge and for the first time in years he had the feeling of effective power in the sphincter area.

The same simple principles are followed in the second stage which, however, as is simpler in point of actual technique. It consisted simply of curving incisions to the depth of the sphincter muscle base, with approach of the ends by sutures. Again, a second buried suture of alloy steel as an anchor and other aids previously employed. Figure 3 is photograph of the condition days after the second stage and shows the transition to firmly closed canal.

It is of course difficult to measure the results of any operation for incontinence in specific and accurate terms, and it is not usual to err on the side of under enthusiasm. It would be preposterous to say this man's sphincter is as good as it ever was. On the other hand his abundant gratitude bespeaks a worthwhile result. We should prefer however to rest on the reasonableness of our approach and upon his trial by those to whom it may appeal.

# SUMMARY

Plastic repair of large defects of the sphincter and muscle is discussed. A very simple yet effective reparative operation is described involving the gradual transplantation in multiple stages of muscle bearing flaps. The chief advantages over the one stage operation in common use are the complete elimination of disastrous postoperative tension and the tedious and mutilating dissection of frayed muscle ends. Also it restricts the necessity of complicated transplantation of extraneous muscle.

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# COMPLICATIONS OF INFEROANTERIOR (AXILLARY) DISLOCATION OF THE SHOULDER JOINT AS DEMONSTRATED BY ROENTGENOGRAMS

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THE grooved or "typical" defect in the humeral head has been described by early anatomists and surgeons. In 1861 Flower reported 41 shoulder specimens which he had collected from pathological museums in London, including cases with fractures of the greater tuberosity, grooved defects in the posterior head of the humerus, and dislocated

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bicipital tendons on the greater tuberosity. In 1880, Eve reported the first proved case of grooved defect. His patient died 12 hours after a train accident in which his shoulder had been dislocated. Postmortem examination of the humerus revealed a groove of recent origin in the latero-posterior portion of the head. Many additional cases were reported by Kuster (1882), Loebker (1887), Schuller (1890), Stoeffel (1895), Francke (1898), and Wendel (1903). Since humeral head resections have been replaced by the conservative methods of Nicola and Bankhard, the operating surgeon has had very little opportunity to observe the defect. Roentgenologists, however, by means

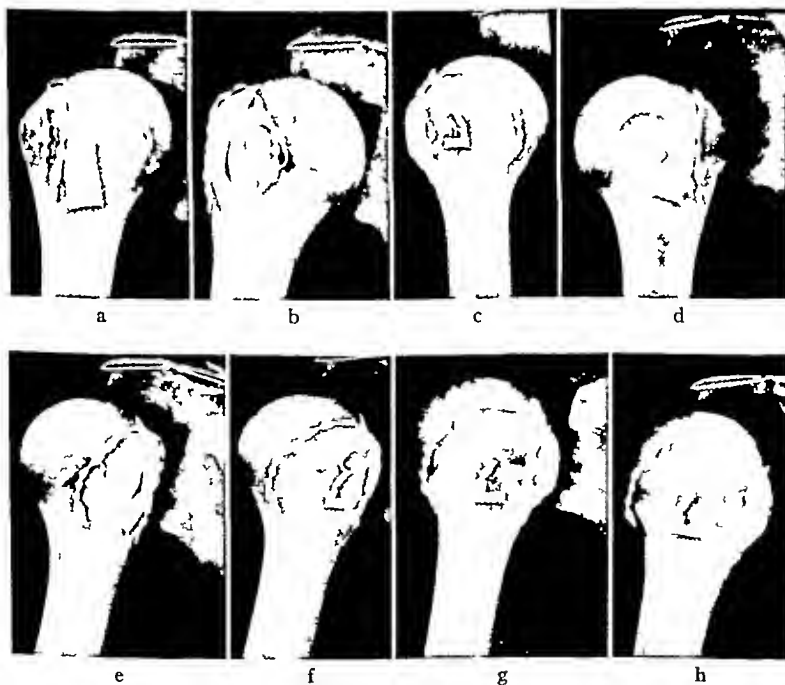


Fig 1 Skeletal roentgen studies beginning in external rotation and gradually externally rotating humerus until complete circle is rotated a, b, Reveal greater tuberosity in profile view f, g, h, Reveal the lateroposterior head of the humerus in profile view

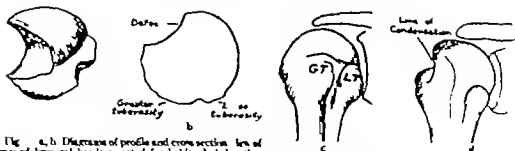


Fig. 1. a, b Diagrams of profile and cross section of grooved humeral heads resected for labrolabral dislocation (modified from Jester and Crueser). c, Diagram of roentgenogram of normal humerus in internal rotation.

d, Diagram of roentgenogram of humerus in internal rotation showing defect.

of fluoroscopy and roentgenograms have been able to diagnose this phenomenon. Perthes (1906) described 2 cases. Schultze (1914) 3 cases. Pils (1935) 15. Hermanson reported that it occurred at the initial examination and need of change appreciable in subsequent dislocations. One of his patients, following fall, revealed a normal roentgenogram of shoulder but several months later after dislocation of the same humerus immediate roentgenogram showed a typical defect.

*Bone anatomy of the shoulder joint.* Thorough knowledge of the topographic anatomy of the shoulder joint and mechanics involved in disloca-

tion is essential to a better understanding of roentgenographic complications which may be the result of inferioranterior or so called subcoracoid dislocations. To simplify topographical roentgenographic anatomy of the shoulder joint, wires are placed about both tuberosities, a smooth wire about the lesser and a twisted wire about the greater (Fig. 2). The letter "L" is placed on the prominent portion of the greater tuberosity and lead foil in the bicipital groove. Roentgenograms are taken with the humerus gradually rotated externally until a 360 degree circle is completed. The first film is taken with the hand in supra-

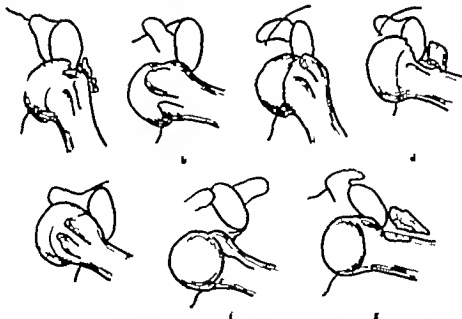


Fig. 3. Diagrammatic sketches from roentgenogram studies revealing anatomic steps in so called inferioranterior or subcoracoid dislocation. a, Subcoracoid external rotation. b, inferioranterior internal rotation. c, inferioranterior external rotation. d, subcoracoid external rotation. e, subcoracoid internal rotation. f, inferioranterior external rotation. g, inferioranterior external rotation.

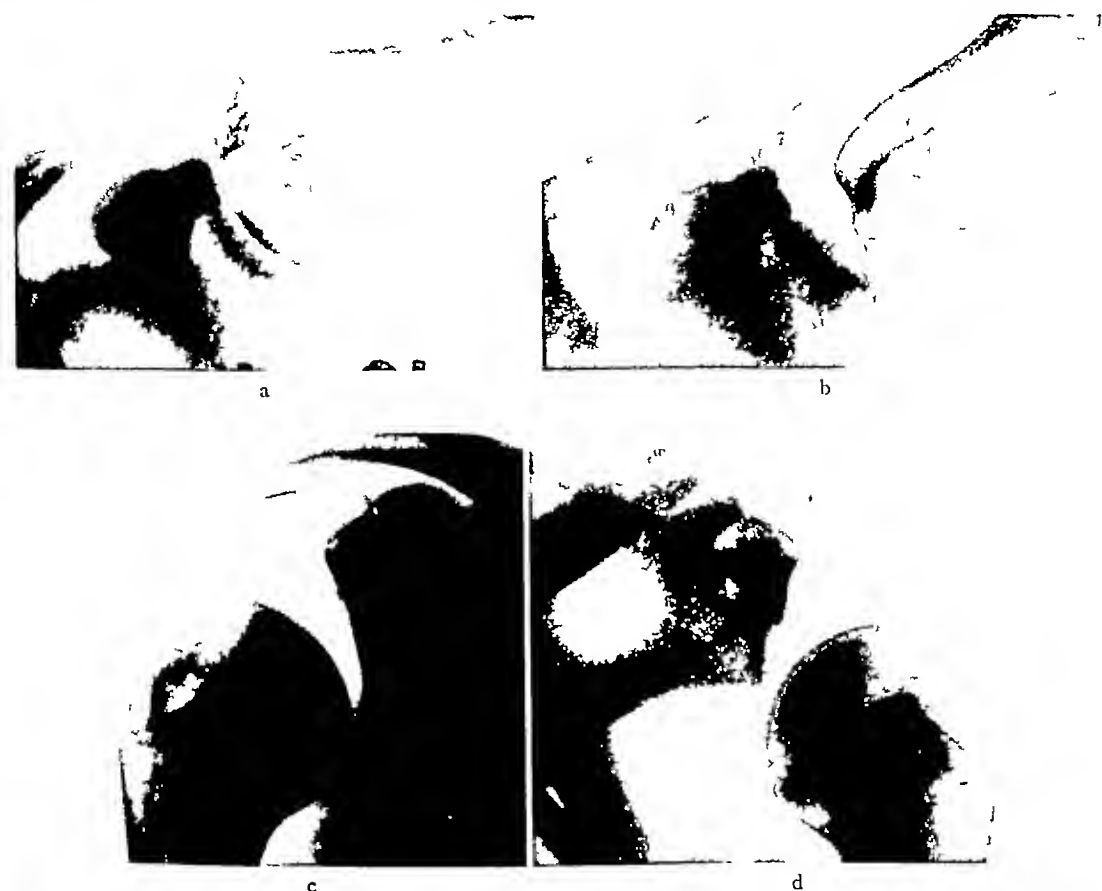


Fig 4 a, Case 1 Left humerus in abduction is within normal limits b, Same humerus with voluntary movement on the part of the patient reveals a subglenoid subluxation c, Case 2 Right humerus in forced extension reveals

a subglenoid subluxation Note the site of the Nicola operation d, Left humerus in forced extension reveals a similar subglenoid subluxation (apparently there is an anomalous maldevelopment of the glenoid articulating rims)

tion, that is, external rotation, and only a small portion of the greater tuberosity is seen in profile view (Fig 1, a) The greater portion of the humeral head consists of the lesser tuberosity and the bicipital groove However, in internal rotation the bicipital groove overlaps the glenoid and the lesser tuberosity is rotated inwardly and posteriorly (Fig 1, f, g, h) The prominent portion of the humeral head consists of the entire greater tuberosity, posterior portion of the anatomical neck, and a part of the lateroposterior humeral head This latter view is especially important inasmuch as this area is very frequently fractured during the course of dislocation If a film were taken in external rotation, this region would not be visualized and the fracture would be missed (5) For this reason, routine films of the shoulder should be taken at least in external and

internal rotation, thus enabling an x-ray demonstration of at least three-fourths of humeral head

Complications of inferoanterior or subcoracoid dislocations are so called compression defect in the lateroposterior head of the humerus (3, 4, 5, 10), fracture of the greater tuberosity and fracture of the inferoanterior lip of the glenoid Somewhat rarer are the findings of cystic changes (3, 4, 5) in the head of the humerus and in the region of the bicipital groove These complications will be considered and illustrated later

*Mechanics of inferoanterior dislocations* The mechanism of the so called inferoanterior (axillary) or subcoracoid dislocation has been described by numerous authors (2, 3, 6, 8, 9, 11, 12) Few of these theories are in agreement and none are entirely acceptable to us (the authors' original conception was not entirely correct) It

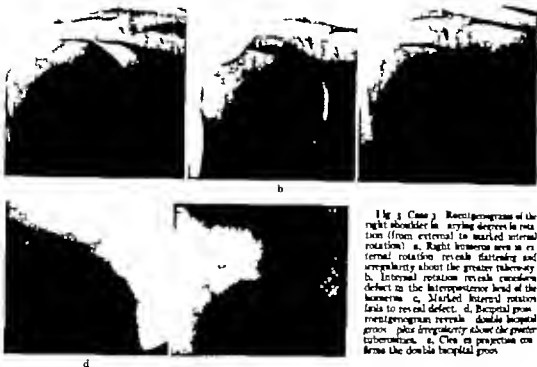


Fig. 5 Case 3. Roentgenograms of the right shoulder in varying degrees of rotation (from external to marked internal rotation). a, Right humerus seen in external rotation reveals flattening and irregularity about the greater tuberosity. b, Internal rotation reveals cuneiform defect in the lateroposterior head of the humerus. c, Marked internal rotation leads to reveal defect. d, Biapical promontogram reveals double biapical grooves plus irregularity about the greater tuberosities. A clear projection confirms the double biapical grooves.

is our belief that the mechanism of dislocation can be demonstrated satisfactorily by means of roentgenograms and, at times, fluoroscopy (Figs. 3, 4, 5, 6, 7, 8, 9, 10). The arm is abducted and internally rotated. Trauma is transmitted along its longitudinal axis, forcing the head inferiorly under the inferior lip of the glenoid (subglenoid dislocation). The lateroposterior portion of the humeral head impinges on the glenoid lip as it is

forced anteriorly through the capsule into the acilla. The inferoanterior lip of the glenoid is very frequently fractured at this stage. Approximately one-half of the so called subcoracoid dislocations are actually inferoanterior or acillar dislocations. The other half follows the path of least resistance anteriorly and superiorly to become true subcoracoid dislocations. Beside its academic value, the latter statement has very little significance as both the acillar and subcoracoid dislocations are reduced in similar way.

The degree of internal rotation determines whether the glenoid lip will impinge on the lateroposterior aspect of the humerus with resultant compression fracture (defect) of which the thickened border is actually compressed spongy bone (7). If the arm is in partial internal or even external rotation, the glenoid lip will impinge on the greater tuberosity producing the typical valium fracture (Figs. 8, 9, and 10, a). Less drastic changes may develop in the lateroposterior part of the spongiosa of the head of the humerus. They are small and sharply circumscribed areas of rarefaction. These are due to small compression fractures or to aseptic necrosis as a result of traumatic disturbance of the vascular supply to this region (Fig. 10, a, b, c, d).



Fig. 6 Case 4. left, External rotation. The bone island seen in the region of the greater tuberosity is of doubtful significance. b, Internal rotation reveals shearing fracture of the lateroposterior head of the humerus with two small bone fragments.



Fig 7 Case 5 a, Right humerus in external rotation reveals minimal changes in the region of the tendinous insertion of the supraspinatus which may be due to tears

b, Internal rotation reveals shearing fracture of the lateral head of the humerus c, Bicipital groove projection reveals spur formation overlying the bicipital groove

In view of our studies of the mechanics of inferoanterior dislocations, it becomes impracticable to explain the grooved defect or other bony changes in the humeral head on the basis of such theories as congenital anomalies, osteochondritis dissecans, posttraumatic inflammation or leverage against the acromion. In spite of the many fractures of the greater tuberosity, we have never seen a fracture of the acromion associated with an inferoanterior dislocation.

*Anatomical roentgenological appearance of the defect* The defect is located posterior and medial to the greater tuberosity on the lateroposterior aspect of the articulating head (Fig 2, a, b). It is cuneiform or navicular in shape and its size varies with the diameter of the head and trauma (4, 5). Average dimensions are 2.5 centimeters in length, 1.5 centimeters in width, and 0.75 centimeters in depth. The defect is demarcated from the surrounding normal bone by sharp or vertical projecting walls which are at right angles to each other. The spongiosa bordering the defect is

compressed and therefore much thicker than usual.

Routine films of the shoulder with the arm held in adduction and external rotation fail to reveal the defect. In external rotation, rarefaction may be seen in the region medial to the greater tuberosity. In large defects, some flattening of the lateral contour of the articular surface may be existent. The defect is seen best with the arm in internal rotation, bringing that portion of the humerus into profile view. A sharp vertical line of condensation extending downward from the top of the head of the humerus, parallel and slightly lateral to the shaft axis, comprises the medial border of the defect. This line of condensation is the result of spongiosa bone compression. In recurrent dislocations, the defect may increase in size and the borders become more sclerotic in appearance. Probably for this reason, earlier surgeons called these defects congenital anomalies.

*Bicipital groove* When the humeral head forces a rent in the anterior portion of the capsule, it is

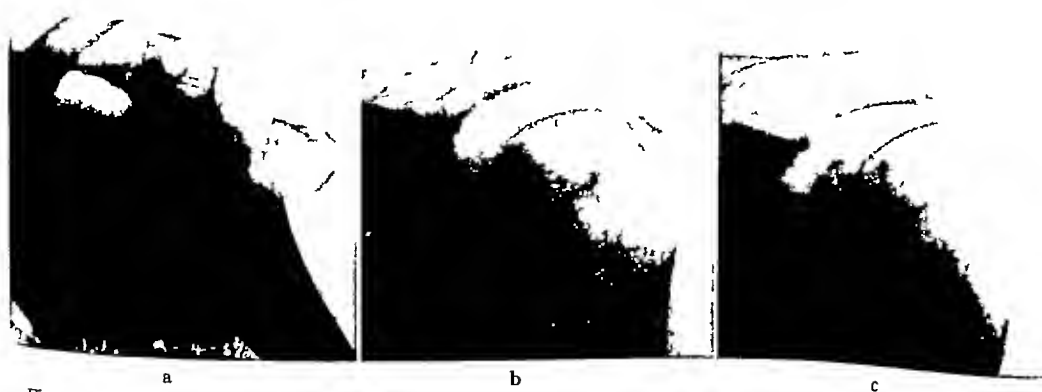


Fig 8 Case 6 a, Subglenoid dislocation, external rotation, with avulsion of the greater tuberosity b, Fragment in position immediately after correction of dislocation c,

Re examination 18 months later reveals complete absorption of the greater tuberosity (Courtesy, Radiology December, 1940)

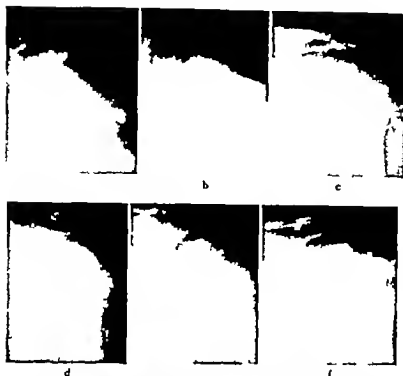


Fig. 9. Case 7. a, Slight external rotation. (b) Anterior fracture of the posterior portion of the greater tuberosity. b, Dislocation has been corrected with fragment in good position. c, Examination 3 months later reveals some depression at the greater tuberosity. d, Examination 6 months later reveals coracoid defect in the later superior head of the humerus. e, Re-examination 1 year later reveals no change in the defect in the later superior head of the humerus. (Lateral rotation fails to reveal the defect.)

reasonable to assume that the bicipital tendon is also injured. We have developed the following technique for visualization of the bicipital groove (10): the arm is adducted to the side of the body in supination (external rotation); the tube is placed slightly external to and below the level of the elbow and the central ray is directed at a tangent upward and medial toward the groove in the humeral head. The cassette is placed on top of the shoulder and at right angles to the longitudinal axis of the humerus (Fig. 4, a, b).

Tangential projection studies of normal shoulders reveal a smooth notch in the center of the humerus which is the bicipital groove (Fig. 13, a). On each side of the groove are smooth prominent walls of the lesser and greater tuberosities. The lesser tuberosity is medial and its wall is more perpendicular than that of the greater tuberosity. Changes as follows may be observed in shoulders with histories of previous trauma whose routine roentgenograms are within normal limits.

Scalloping and irregularity of the groove which may account for tendon fraying (sometimes a small osteophytic spur 1 to 4 millimeters in length is noted projecting into the groove).

2. Presence of one or more additional grooves due to tendon dislocations.

3. Formation of new bone in old groove as result of new groove. Shallow old groove as a result of bicipital tendon disuse when the tendon dislocates and forms a new groove.

#### CASE REPORTS

**CASE 1** J. L. B. male, aged 24 years, injured his left shoulder as child. Examination revealed no gross friction noise as the shoulder was pushed forward by voluntary motion. Clinically there appeared to be an anterior subluxation caused by rubbing of the humeral head on the anterior cartilaginous portion of the glenoid rim. However roentgenograms in both positions revealed that instead of being an anterior subluxation, it actually was subglenoid subluxation (Fig. 4, a, b).

**CASE 2** H. C. male, aged 37 years, injured his right shoulder many years prior to admission when he struck another person. Since that time he has had repeated dislocations even at the slightest efforts, such as raising chair from the floor. He reduced the dislocation himself by the Kocher maneuver. Roentgenograms in marked extension revealed that not only was there partial subglenoid subluxation of the right shoulder but also, the left humerus was extended, corresponding subluxation (Fig. 4, c, d).

This case exemplifies the need of individualizing each case before attempting therapy. In this case, Nick is operation on the right shoulder had been done and as might have been anticipated, the patient immediately redislocated his shoulder when his arm was removed from the sling.

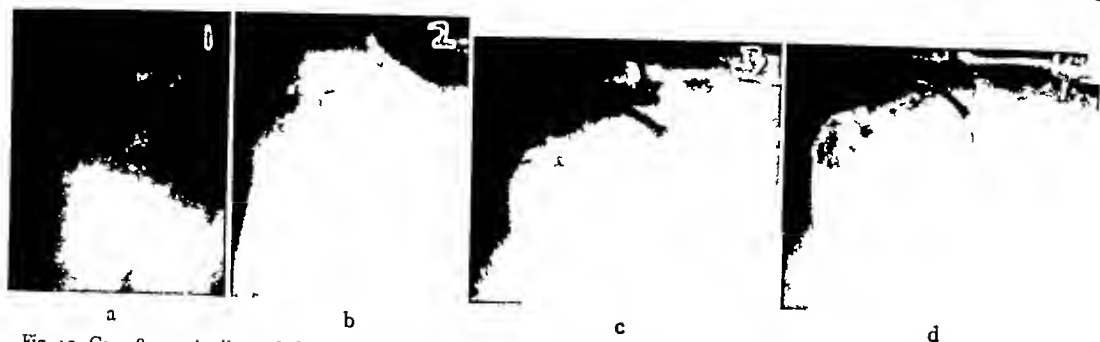


Fig 10 Case 8 a, Axillary dislocation right humerus b, After correction of the dislocation there is rarefaction in the lateral portion of the humeral head c, Re examination 3 months later reveals moderate flattening of the greater

tuberosity with multiple circular areas of rarefaction in the lateral humeral head d, Examination 6 months later reveals increase in multiple areas of rarefaction in the lateral portion of the humeral head

CASE 3 J Mac, male, aged 29 years, stated that at the age of 10 years he fell off an acrobatic bar and was temporarily unconscious. He did not know whether he had had a dislocation. In 1935, he was troubled with neck pain and later a similar pain occurred in his left shoulder. His shoulder joints were stiff and fixed in an adducted position. However, he had been getting more motion back into the joint. Roentgenograms taken on August 7, 1941, in external rotation revealed minimal rarefaction in the lateral portion of the humerus and some tendency toward flattening of the greater tuberosity. In moderate internal rotation, a moderate size defect was seen in the lateroposterior head of the humerus. In marked internal rotation, the defect was not seen (Fig 5). Bicipital groove projection revealed irregularity and a double groove (Fig 5, d). Cleaves projection confirmed the double bicipital groove as a result of previous trauma and probable dislocation of the tendon (Fig 5, e).

This case illustrates the fact that the defect or fracture will occur on that portion of the humerus which comes in contact with the glenoid lip at the time of dislocation. The contact points between the humerus and the glenoid lip are determined by the amount of rotation of the humerus. In external rotation the greater tuberosity will be involved. In complete internal rotation the lateroposterior head of the humerus will be involved.

The following case illustrates the shearing force the glenoid lip may have when it is impinged on by the humeral head.

CASE 4 J L, male, aged 40 years, chronic alcoholic, stated that he had had at least 20 dislocations of both shoulders. Roentgenogram of the left shoulder in external rotation revealed nothing unusual, except possibly a small circular area of increased bone density about 2 centimeters in diameter in the midportion of the humeral head which might have been attributed to bone island (Fig 6, a). However, the film in internal rotation revealed a shearing fracture of the posterior head of the humerus with two residual bone fragments (Fig 6, b).

CASE 5 J M, male, aged 28 years, dislocated his right shoulder approximately 1 year prior to his entrance to the hospital. Dislocation was corrected. Subsequently the patient complained of pain in this shoulder on movement. In external rotation, roentgen examination was negative (Fig 7, a). Internal rotation revealed a shearing fracture of the lateroposterior head of the humerus (Fig 7, b). Bicipital groove film revealed osteophytic changes overlapping

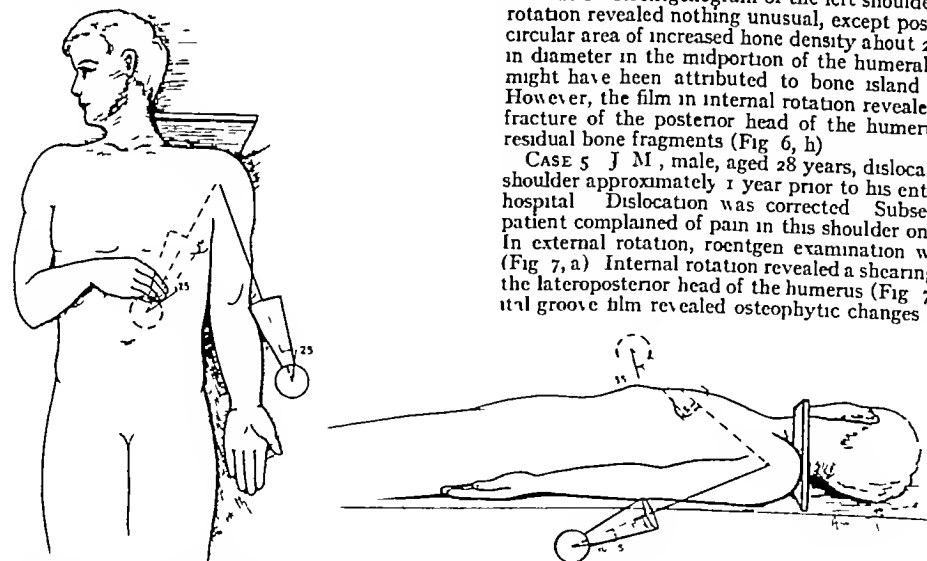


Fig 11 Diagrams illustrating bicipital groove technique. Dotted line technique has been discarded as impracticable. (Courtesy Radiology, June, 1941)





Fig. 2. a, Roentgenogram of normal groove. Smooth indentation is the bicipital groove. Lesser tuberosity is more prominent than the greater. b, Case 6. Bicipital groove projection right shoulder reveals tendency toward spur formation on the lesser tuberosity overlying the groove.

the groove (Fig. 7.) These changes probably account for pain on movement.

CASE 6 J. J. male, aged 50 years, had left subglenoid dislocation on August 4, 1937 (Fig. 8, a, b). The patient was not seen for a year and subsequent examination and films on February 4, 1939, revealed that the large ulion fragment of the greater tuberosity was completely absorbed and there was marked loss of function of the shoulder primarily limited to abduction and rotation (Fig. 8, c).

CASE 7 E. B. female, aged 50 years, dislocated her left shoulder. Roentgenogram revealed an inferoposterior dislocation of the humerus in partial internal rotation. With an ulion fracture of the posterior portion of the greater tuberosity as well as the lateroposterior portion of the humeral head (Fig. 9). Subsequent films taken over a period of a year revealed gradual absorption of the fragments with resultant smooth defect about three-fourths centimeter in diameter in the lateroposterior portion of the humeral head there was no evidence of fragmentation (Fig. 10, d, f). The shoulder function as within normal limits. Apparently the external rotator muscles are not involved.

CASE 8 W. H. male, aged 30 years, gave history of dislocating his right shoulder on April 30, 1935, with typical inferior-terior dislocation (Fig. 11, a, b). Subsequent films taken July 2, 1935, and October 9, 1935, revealed marked increase in rarefaction in the lateral portion of the head of the humerus with tendency toward compression defect (Fig. 10, c, d).

CASE 9 K. C. M. male, aged 66 years, complained of pain on movement of the right shoulder. There was no history of previous trauma. Routine films in external and internal rotation were negative. Bicipital groove film revealed minute areas of rarefaction bordering the groove with tendency toward osteophyte formation on the medial border of the groove (Fig. 12, b).

CASE 10 C. B. male, aged 65 years, gave history of being thrown from his horse 32 years ago. After the time the patient complained of occasional pain in the shoulder joint with minimal limitation of motion. Examination of the left shoulder on February 9, 1941, revealed moderate atrophy of the left deltoid and pectoral muscles. There was moderate limitation of the humerus to abduction and external internal rotation. Routine films in external and internal rotation were negative. Bicipital groove roentgenograms revealed tendency toward scallop formation on the lesser tuberosity with an attempt toward spur formation of the lesser tuberosity bridging the bicipital groove (Fig. 13, c).

With several circular areas of rarefaction in the tuberosity. Case 10. Bicipital groove projection of the left shoulder reveals scallop formation over the lesser tuberosity plus tendency toward spur formation of the lesser tuberosity bridging the bicipital groove.

#### SUMMARY AND CONCLUSIONS

1. Thorough anatomical knowledge is a requisite to better understanding of complications in shoulder dislocations as shown by roentgenograms.

2. Mechanics of dislocations as previously taught is apparently erroneous and more careful study should be given to the mechanical anatomy in order to apply suitable therapeutic measures in correcting and preventing recurrent dislocations.

3. Defect in the lateroposterior head of the humerus, avulsion fracture of the greater tuberosity, fractures of the inferoposterior glenoid lip, and cystic areas in the lateral head of the humerus are some of the complications associated with inferoposterior dislocations of the humerus. (1) In cases of posttraumatic pain, bicipital groove roentgenograms should be taken when routine films fail to reveal any evidence of abnormality. (Routine films include one film in external rotation, second in extreme internal rotation and a third in lateral view.)

Far too often posttraumatic pain is attributed to a psychotic state or anticipation of compensation on the part of the patient.

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# BEADED WIRES IN CLOSED REDUCTION OF FRACTURES OF THE LEG

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## METHOD

WITH the introduction of so called nonirritating metals there has been a great increase in the number of open reductions of fractures of the leg. Simultaneously, there has been a condemnation by a few authors of all closed methods of reduction of fractures of the tibia (1, 2, 3). The blanket indictment of the closed method is unfair as it is still most desirable, and it is hoped this paper will prove such claims and offer a simple positive method for handling fractures of the leg.

A true transverse fracture of the tibia usually can be reduced by manipulation and held in a plaster cast, allowing early weight bearing. However, such management is not often possible in spiral, oblique, and comminuted fractures. To overcome the difficulties in maintaining the position of these fragments, beaded Kirschner wires have been employed in conjunction with closed reduction. The beaded wire was designed by Drs J E M Thomson and C F Ferciot and consists of a metal bead five thirty-seconds of an inch in diameter which has been brazed on to a plain Kirschner wire. Thomson and Ferciot used these wires in fixation of fractures after reduction had been accomplished by open operation, but in my experience open reduction of fractures of the shaft of the tibia has not been necessary.

Closed reduction of fracture of the shaft of the tibia with the use of the beaded wires has been used in 19 cases, 7 of which had been compounded.

Before the initial steps in reduction are undertaken, a careful study of the roentgenograms is most important. The reason for this is to determine the shape, position, and number of the fragments to ascertain the direction of insertion of the beaded wires.

With the patient on a fracture table and under general anesthesia, a plain Kirschner wire is drilled through the os calcis. A bow is then applied and fastened to the foot piece of the fracture table after which screw traction is applied until the fragments can be gently manipulated into position.

The site of election for drilling one beaded wire can be easily determined by palpating the end of a long fragment aided by the knowledge received from the roentgen examination. However, the area may be selected by use of the fluoroscope.

The beaded wire is then drilled into the bone. A puncture wound must be made in the skin to admit the bead, but it is not necessary or recommended that the incision be any deeper than the skin. When the bead strikes the bone, further progress of the wire is naturally stopped thus indicating satisfactory insertion. With this wire acting as a landmark the remaining beaded wire or wires to be drilled are introduced alternately in opposite directions.

A Kirschner bow with a Thomson attachment or the double transverse traction bow is then applied and the fragments are brought together (Fig 8). A long leg cast is applied and after it has set tightening bolts (5) are fastened to the protruding wires in order to hold the beads firmly against



Fig 1 Female, aged 49 years a, Oblique fracture of tibia, b, reduction—2 beaded wires, c, end result



Fig. 2. Female, aged 38 years. a, Spiral fracture of tibia. b, reduction—3 headed wires, c, end result.



Fig. 3. Female, aged 43 years. a, Comminuted spiral fracture of tibia and fibula. b, reduction—3 headed wires, c, end result.



Fig. 4. Male, aged 33 years. a, Comminuted spiral fracture of tibia. b, reduction—3 headed wires, c, end result.

the bone. A washer or slotted metal piece may be placed between the bolt and the cast so that the latter will not become indented.

A long metal U shaped 12 in. high small holes have been drilled at quarter inch intervals incorporated in the cast for use in compound frac-



Fig 5 Female, aged 40 years a, Bumper fracture of tibia and fibula unsuccessfully reduced and in a cast, b, reduction—3 beaded wires, c, end result

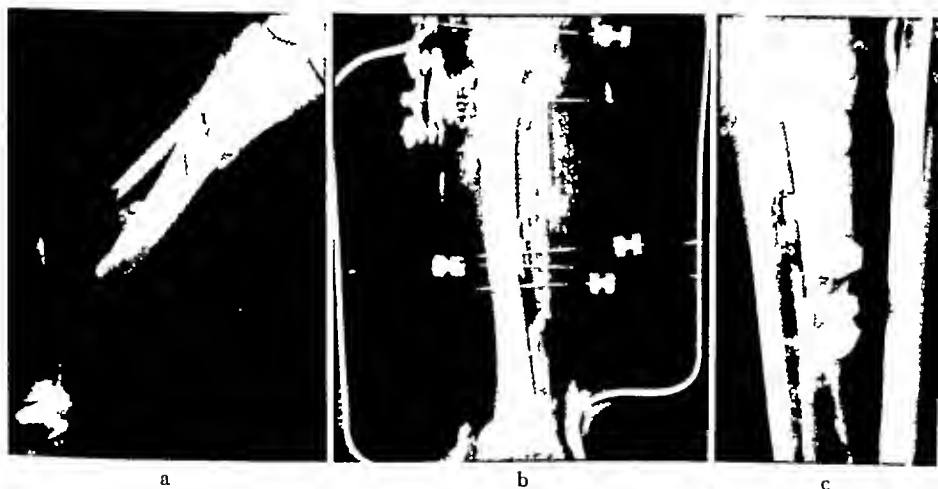


Fig 6 Male, aged 58 years a, Compound fracture of tibia and fibula with massive loss of soft parts, b, reduced—5 beaded wires 3 of which are in turn wired to a plain 'U' bar incorporated in the cast

tures (Fig 7) The wires are then directed through one of the holes and the tautening bolts are attached to the wires on the outside of the bar. By this means it is not necessary to use counter pressure on the cast by the bolt which allows the removal of the plaster over the denuded area so that the wound may be dressed.

After reduction roentgenograms are made for confirmation of position and, if there has not been adequate transverse traction at the time of reduction, the slack can be taken up by the screw in the tautening bolt.

It is not necessary to apply skin-tight or snug fitting casts, but on the contrary a generous

amount of padding is recommended which allows for possible swelling of the extremity. The quantity of sheet wadding used does not interfere with the immobilization of the leg. Although the function of the cast is to support the extremity, this is not of primary importance. The salient point is that it serves as a reinforcement against which the tautening bolts maintain continuous opposing traction of the wires. The fixation, thus being against the bone, the cast is not necessary for maintenance of position of the fragments.

After recovery from the anesthetic the patient may be ambulatory and leave the hospital. Weight bearing with crutches is permitted. After 5 or 6

lowing purposes (1) to quiet apprehensive patients so that spinal anesthesia might be induced, (2) to supplement inadequate spinal anesthesia, (3) to quiet patients who became apprehensive or nauseated during operation, and (4) to prolong anesthesia.

Sibley and Tuohy also recently have advocated the use of intravenous anesthesia in conjunction with spinal anesthesia. Sibley employed pentothal sodium as the intravenous anesthetic. He used a Y-shaped tube so that physiological saline solution might be administered continuously. The solution of pentothal sodium was administered by means of a 30 cubic centimeter syringe, which was attached to the other arm of the Y tube. This permitted the author to administer the solution of pentothal sodium intermittently in order to keep the patient anesthetized or in a semistuporous state throughout the operation.

In the hands of an experienced anesthetist intravenous anesthesia and cyclopropane inhalation anesthesia probably are equally satisfactory for use in conjunction with spinal anesthesia. Both of these methods permit the administration of an abundant amount of oxygen and both supplant the deficiencies of spinal anesthesia. In fact, 100 per cent oxygen can be administered in cases in which pentothal sodium is administered intravenously. According to Wiggin balanced spinal anesthesia possesses the following advantages: (1) the patient is more completely under the control of the anesthetist, (2) the psychic factors of apprehension, restlessness and undue stimulation are completely allayed, (3) respiration can be controlled by the administration of oxygen, (4) the blood pressure and pulse remain more stable than they do with any other method of anesthesia, and (5) complete relaxation can be obtained without the administering of large doses of the spinal anesthetic.

When pentothal sodium and cyclopropane are administered by the intravenous and inhalational methods respectively in conjunction with spinal anesthesia, pentothal sodium has the following advantages: (1) it is nonexplosive (2) it appeals to the patient as the use of the anesthetic mask can be eliminated, (3) its action is more rapid than that of cyclopropane (4) it facilitates maintaining a very light plane of anesthesia in cases in which this is desirable and (5) it appears to contribute definitely to the alleviation of postoperative shock.

According to Keen, the barbiturates have certain disadvantages when used in conjunction with spinal anesthesia. Of the disadvantages listed by this author we may mention the following: (1)

singultus occasionally may occur in cases in which crystal soluble is used, (2) the danger of pulmonary complications may be increased, and (3) as barbiturates are detoxicated chiefly in the liver they should not be administered in cases of extensive damage of the liver. Recent investigation (1 to 10), however, has demonstrated that pentothal sodium can be administered safely in cases in which severe hepatic deficiency is present. Our experience indicates that the incidence of pulmonary complications is no greater in cases in which pentothal sodium is administered intravenously to supplement spinal anesthesia than it is in cases in which inhalation anesthesia is used for this purpose.

The advantages and disadvantages of spinal anesthesia are well known. If the anesthetist is skilled and if safe doses of the anesthetic agent are employed, there should be little danger of respiratory paralysis or of a decrease in the blood pressure, but nausea, vomiting, and retching frequently cannot be prevented or controlled. In certain cases, difficulties arise when it is necessary to prolong the operation or when the operative procedure involves tissues or organs situated above the planned level of anesthesia. These difficulties frequently necessitate the use of supplemental anesthesia but continuous spinal anesthesia has tended to abate the need for concern over duration of anesthesia in long or potentially long operations. However intravenous anesthesia also may be used advantageously with continuous spinal anesthesia.

In cases in which intravenous anesthesia is used in conjunction with spinal anesthesia, the intravenous anesthetic should be administered cautiously as the spinal anesthesia will have caused some depression and will have increased the susceptibility of the patient to other anesthetic agents. In order to prevent emotional disturbances and nausea, the intravenous anesthetic should be administered before the incision is made.

It has been said (7) that in order to facilitate operations on the colon it is the anesthetist's responsibility to prevent soiling of the peritoneum in so far as it is possible to do so by keeping the patient from straining. Spinal anesthesia is one of his most valuable aids in accomplishing this and if it cannot be accomplished with spinal anesthesia alone other methods must also be used.

During the past 5 years we have been using combination of spinal anesthesia and intravenous anesthesia for operations on the colon. Pentothal sodium has been administered intravenously and procaine hydrochloride or metacaine has been administered intraspinally.



TABLE II—AVERAGE BLOOD PRESSURE IN CASES IN GROUP 1 AND GROUP 2

	Group 1*		Group 2†	
	Cases	Blood pressure, mm. of mercury	Cases	Blood pressure, mm. of mercury
		Systolic      Diastolic		Systolic      Diastolic
Before operation	38	76.5    54.8	300	70    57
Immediately after operation	37	76    55	99	64.8    43
One-half hour after operation	94	74    53	94	70    47
One hour after operation	97	72    52	93	71    46.7
First day after operation	37	72    52.8	90	73    49.8

\*One hundred cases in which intravenous anesthesia was used in conjunction with spinal anesthesia.

†One hundred cases in which inhalation anesthesia was used in conjunction with spinal anesthesia.

Infection is begun the patient is told to start counting aloud. The injection is continued until the patient stops counting. A total dose of 5 to 10 cubic centimeters of the solution usually is required to cause the patient to stop counting. The needle is kept in the vein and additional amounts of the solution are injected if necessary. The plane of anesthesia should be just deep enough to prevent the patient from vomiting. A high concentration of oxygen (100 per cent) is administered throughout the operation. If it becomes evident that the desired plane of anesthesia can not be maintained without the injection of excessive doses of pentothal sodium, a mixture of equal parts of nitrous oxide and oxygen is administered by inhalation in addition to the intravenous pentothal.

If the decrease in the patient's blood pressure becomes severe .75 milligrams of ephedrine sulfate is injected intravenously or 0.5 to 0.3 cubic centimeter of a 1 per cent solution of neosynephrin is administered intramuscularly. The dose of ephedrine sulfate is repeated once if necessary.

It has been the opinion of one of us (Mayo) that the results obtained in cases in which this method was used have been better than those obtained formerly, that is, when a combination of spinal anesthesia and inhalation anesthesia was being used. In order to determine the relative value of the two methods, we decided to review two comparable groups of cases. Group 1 includes 100 cases in which operations on the colon were performed with spinal anesthesia combined with intravenous anesthesia, and group 2 includes 100 cases in which a combination of spinal anesthesia

TABLE III.—PULSE RATE IN CASES IN GROUP 1 AND GROUP 2

Day of operation	Group 1*		Group 2†	
	Cases	Average pulse rate per minute	Cases	Average pulse rate per minute
One-half hour after operation	37	90.8	91	97
One hour after operation	93	89	91	96
First day after operation	100	90.8	100	95
Second day after operation	100	91	99	93.8
Third day after operation	100	90	99	
Fourth day after operation	99	89.3	97	88

\*One hundred cases in which intravenous anesthesia was used in conjunction with spinal anesthesia.

†One hundred cases in which inhalation anesthesia was used in conjunction with spinal anesthesia.

and inhalation anesthesia was used for similar operations.

The cases in group 2 were observed at an earlier date than were those in group 1. During the period in which the cases in group 1 were observed, it has been our practice to give a transfusion of at least 500 cubic centimeters of blood in the course of or after the completion of the operation in all cases in which combined abdominoperitoneal resection or partial colectomy was performed and in certain other cases in which major operations were performed on the colon. A transfusion of blood was given during or very soon after operation in 57 per cent of all the cases in group 1 (Table I) but in only 34 per cent of the cases in group 2. A blood transfusion was given, or fluids were administered intravenously during or very soon after operation, or both of these procedures were employed in 69 per cent of the cases in group 1 but in only 47 per cent of the cases in group 2. Another difference is that oxygen was administered after operation, by means of a mask or tent, in a higher percentage of the cases in group 1 than it was in the cases in group 2. The relative influence of these differences in treatment in the two groups of cases will be considered in our analysis of the results obtained.

With the exception of the method of anesthesia employed and the differences in treatment which we have just mentioned, the cases comprising the two groups are essentially similar. The ages of the patients, the anesthetic agents employed, the various operations performed, the stimulants administered and the postoperative treatment em-

ployed are shown in Table I. It will be noted that the ages of the patients were practically the same in each group. The technique of intraspinal injection was the same in all cases. The average amounts of procaine hydrochloride or metycaine injected intraspinally were as follows: 127.9 milligrams in the cases in group 1 and 132.2 milligrams in the cases in group 2.<sup>1</sup> The average total dose of pentothal sodium administered intravenously in the cases in group 1 was 0.919 gram. All of the operations were performed by one of us (Mayo).

The average duration of anesthesia was 69.3 minutes in the cases in group 1 and 66.9 minutes in those in group 2.

The incidence of postoperative pulmonary complications was practically the same in the two groups of cases (Table I). It will be noted that two pulmonary complications, namely, atelectasis and pneumonia, occurred in one case. The corresponding incidence of postoperative pulmonary complications tends to confirm the frequent observation that the incidence of these complications depends upon the type of operation and age of the patient rather than upon the choice of anesthetic agent or method.

The average values for the systolic and diastolic blood pressures, the average pulse rate and the average respiratory rate, as determined before operation and at various intervals after operation, are shown in Tables II, III, and IV, respectively. It will be noted that there was very little difference in the respective findings in the two groups of cases before operation. During the first hour after operation the average decrease in the blood pressure was definitely greater in group 2 than it was in group 1 (Table II). Although this difference in blood pressure may be partially attributable to increased use of blood transfusion and the intravenous administration of fluids in the cases in group 1, it is our opinion that much credit must be given to the intravenous administration of pentothal sodium and to the continuous administration of 100 per cent oxygen.

In Table II it will be noted that immediately after operation the average decrease<sup>2</sup> in the systolic blood pressure was greater in the cases in group 2 than it was in the cases in group 1. Half an hour after operation, the average decrease in the systolic pressure was 15.5 millimeters in group 1 and 23.1 in group 2. One hour after operation the average decrease was 4.1 millimeters in group 1 and 18.9 millimeters in group 2. However, the

TABLE IV —RESPIRATORY RATE IN CASES IN GROUP 1 AND GROUP 2

Time after operation	Group 1*		Group 2†	
	Cases	Average respiratory rate per minute	Cases	Average respiratory rate per minute
One half hour	86	20.9	90	21.2
One hour	94	20.8	91	20.5
First day	100	19.5	95	20.5
Second day	99	20.1	94	20.6

\*One hundred cases in which intravenous anesthesia was used in conjunction with spinal anesthesia.

†One hundred cases in which inhalation anesthesia was used in conjunction with spinal anesthesia.

average decrease during the first day after operation was approximately the same in the two groups of cases, that is, 6.5 millimeters in group 1 and 7.4 millimeters in group 2.

As was to be expected, there was a concomitant rise in the average pulse rate after operation (Table III). Half an hour after operation, the average increase in the pulse rate per minute was 2.3 in the cases in group 1 and 1.2 in the cases in group 2. One hour after operation, the respective increases were 1.4 and 8.2. When blood pressure falls, the expected physiological response is an increase in the pulse rate. This response was observed in both groups of cases but on the first day after operation, when the average decrease in the systolic blood pressure was approximately the same in the two groups of cases, that is, 6.5 millimeters in group 1 and 7.4 millimeters in group 2, the average increase in the pulse rate per minute was 4.3 in group 1 and 13.8 in group 2. This variation of the difference in the average pulse rate in the two groups of cases persisted for the first 4 days after operation. This indicates that the general condition of the patients in group 2 was less satisfactory than was the condition of the patients in group 1. We believe that the more favorable response of the pulse rate in group 1 is attributable to the use of pentothal sodium and to the improvement in the treatment employed immediately after operation.

The important differences in the two series of cases were in the incidence of nausea and vomiting (Table I), in the duration of the period of recovery, and in the mortality rate. In group 1, 10 per cent of the patients had nausea during or after operation and 8 per cent vomited, while in group 2, 38 per cent of the patients were nauseated and 36 per cent vomited. Such a reduction in the incidence of nausea and vomiting is of great importance not only from the standpoint of the

<sup>1</sup>As there is a difference of only 10 per cent in the doses of these drugs the doses have been averaged together.

<sup>2</sup>The average decrease in the blood pressure is based on the reading obtained before operation.



patient's comfort but also in facilitating the surgeon's work, prevention of soiling of peritoneum, and lessening the strain upon the wound.

The shorter duration of the period of recovery from anesthesia in group 1 is another difference, which is due almost solely to the use of pentothal sodium with spinal anesthesia. In group 1 the patients were awake on an average of 27 minutes after operation while in group 2 it was 45 minutes before they responded. A shorter period of recovery is of great advantage of course in rendering the patient more co-operative and also in allowing a more rapid return to normal of muscle tone and other physiological processes.

However, one of the most striking differences in the two series is in the mortality rate. In group 2 it was 12 per cent while in group 1 it was only 5 per cent. Whereas we realize that the other differences in the treatment of these two groups of patients are significant, we feel that the combination of intravenous anesthesia with spinal anes-

thesia is of paramount importance in producing these favorable results.

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# INTRAVENOUS AMINO ACID ADMINISTRATION IN SURGICAL PATIENTS USING AN ENZYMATIC CASEIN DIGEST

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**M**AINTENANCE of an adequate protein intake in surgical patients is necessary for proper wound healing, for replacement of tissues lost in metabolism, and for the protection of body tissues, particularly the liver. Because of the relatively small reserve of protein available for this purpose, serious protein deficiencies may develop fairly quickly in those patients in whom feeding by mouth is either impossible or unwise. The frequency and seriousness of these deficiencies, resulting particularly in hypoproteinemia, have been repeatedly emphasized.

Efforts to preserve nitrogen equilibrium by parenteral protein administration have occupied the attention of numerous investigators in recent years, and it has now become possible to maintain nitrogen metabolism either by plasma infusions or by the intravenous administration of amino acids. Plasma transfusion is a life-saving procedure when acute reduction of plasma volume occurs such as in traumatic shock or burns. The use of plasma as a nutritive agent, however, is impracticable because of the large quantity necessary for such a purpose. (In our cases, the quantity of plasma recovered from approximately 2 liters of blood would have been necessary to supply an amount of protein equal to that given each day as amino acid.) Furthermore, plasma proteins are less satisfactory than amino acids for nutrition since they are not available for utilization by the tissues until they have been hydrolyzed.

Elman and Weiner (7) were the first to give amino acids intravenously to human beings. They demonstrated satisfactorily that a mixture of amino acids derived from the acid hydrolysis of casein to which tryptophan and cystine had been added was utilized by the body.

The mixture of amino acids—amigen—used in this study was prepared by the enzymatic hydrolysis of casein. Tryptophan and cystine are not destroyed by the enzymes and need not be added, thus considerably lowering the cost of manufac-

ture. The mixture is a complete one which is nonantigenic and which, as the sole source of nitrogen in experimental animals, will support a normal rate of growth (17).

We have administered the amino acid mixture intravenously to a series of surgical patients (chiefly postoperative), receiving no other protein. Included in this series were patients with the following conditions: appendiceal peritonitis, carcinoma of the stomach, gastric resection for duodenal ulcer, perforated peptic ulcer, ruptured ileum, intestinal obstruction, carcinoma of cecum, and polyposis of the colon. In this study it has been our purpose to observe the effect of such injections of amino acid on the clinical course and on the plasma proteins and to determine the safety of the procedure as judged by reactions and complications.

The amino acid mixture has been supplied as a powder or as a sterile 10 per cent solution in liter flasks. When using the powder our practice has been to prepare a 10 per cent stock solution in freshly distilled pyrogen-free water which is then sterilized by passing through a Seitz filter. The solution for intravenous use was prepared by adding 300 cubic centimeters of the 10 per cent stock solution to 700 cubic centimeters of 10 per cent dextrose in saline. When using the 10 per cent solution as supplied by the manufacturer a similar dilution was made. One liter of this 3 per cent amino acid solution was then given intravenously as rapidly as it would pass by gravity through a 20 gauge needle, the average time of injection being about 60 minutes. Two such liter infusions were given daily to the adults in this study while children received 1 liter daily.

## REACTIONS

Three hundred and sixty-two intravenous infusions of this mixture have been given to 30 patients as the only source of nutrition over an average period of 7 days. The longest period of administration was 14 days, the shortest 3 days.

We have observed 3 chills which were followed by a temperature elevation and 1 elevation of tem-

TABLE I.—NITROGEN BALANCE STUDIES IN AN AFEBRILE POSTOPERATIVE PATIENT WITH MALFUNCTIONING GASTROENTEROSTOMY STOMA

Postoperative day			5	6	7	8		10	
Blood samples	Total proteins (gms.)		8			8			5.4
	Albumin					3			6
	Globulin					5			5
	Red blood cells		4-4.4			90			29
	Hematocrit		34.8			30			31
Total nitrite (intravenous)	Glucose (gms.)	1.00	1.00	1.00	1.00	20	1.00	1.00	20
	Vitamins	B (mgm.)	50	50	50	50	50	50	50
		C (mgm.)	100	100	100	100	100	100	100
		Ascorbic acid (mgm.)	15	15	15	15	15	15	15
	Ammonia (gms.)	50	50	50	50	5	50	50	50
	Total nitrogen (gms.)	7	7	7	7.5	25.5			
Output urine	Total		170	24.30	120	2000	17.40	2000	
	Total nitrogen		5	5.5					
Nitrogen balance (gms.)			+0	+2.4	+2	+0.5	+0.6		7
(Adequate)									

perature without chill or subjective discomfort. In spite of the fairly rapid rate of injection, we have encountered no nausea, vomiting, abdominal pain, or flushing. Occasionally patients complained of feeling of warmth during the injection, but this sensation was not unpleasant. After repeated injections of the amino acid solutions into the same vein, thrombosis of the vein usually developed but by careful selection of the site of injection thrombosis was no more frequent than when plain 10 per cent dextrose solutions were

used. Clinically patients who received the amino acids appeared less ill and subjectively felt better than those who had not received them. No reactions have occurred which would indicate that amigen is antigenic.

#### EVIDENCE OF UTILIZATION

Nitrogen balance studies were carried out in all of the patients studied. In those with low nitrogen outputs nitrogen balance was easily achieved (Table I). In all of the patients with fever and

TABLE II.—NITROGEN BALANCE STUDIES IN A POSTOPERATIVE PATIENT WITH APPENDICULAR PERITONITIS

Postoperative day						7	8		
Blood samples	Total proteins (gms.)								
	Albumin								
	Globulin								8
	Red blood cells					90	4.4		
	Hematocrit	33		33	33	3		33	
Total nitrite (intravenous)	Glucose (gms.)	1.00	10	1.00	10	1.00	1.00	1.00	1.00
	Vitamins	B (mgm.)	50	50	50	50	50	50	50
		C (mgm.)	100	100	100	100	100	100	100
		Ascorbic acid (mgm.)	15	15	15	15	15	15	15
	Ammonia (gms.)	50	50	50	50	50	50	50	50
	Total nitrogen (gms.)								
Output urine	Total		260	26	26.4	1600	1300	170	100
	Total nitrogen (gms.)				1.7	20.5	15	8	17
Nitrogen balance (gms.)			87	30		37		23	

(Adequate)

most of the patients immediately following operation large nitrogen excretions (in one case 25 gms in 24 hours) made it impossible to attain nitrogen balance on the doses of amino acid given (Table II)

Although all injections were given as rapidly as they would pass by gravity through a 20 gauge needle, the amino acids were not spilled into the urine in significant quantities. Estimation of amino nitrogen in 24 hour specimens from most of the patients studied in no case gave readings higher than 400 milligrams of amino acid nitrogen in the urine per day. The average excretion per day was 163 milligrams.

Evidences of serum protein regeneration following intravenous amino acid administration has been proved in dogs by Elman (5) and also by Whipple and his co-workers. In our patients who were not running fever, we were able to demonstrate a rise in serum protein in the blood when amino acids were the sole source of nitrogen intake as shown in Figure 1. On the amount of amino acid used, we were unable to demonstrate a rise in serum protein in those whose courses were febrile.

#### OBSERVATIONS

Our experience indicates that this amino acid solution prepared by the enzymatic hydrolysis of casein may be given intravenously without significant reaction to surgical patients and that it is retained and apparently utilized by the body. In afebrile patients when it represents the sole source of nitrogen replacement, nitrogen balance has been attained and definite regeneration of plasma protein has been demonstrated.

In all cases adequate amounts of glucose must be given along with the amino acids for their "sparing" action of the protein. Without carbohydrates the protein administered may be used solely for energy and in addition tissue proteins also may be broken down and used for this purpose. With glucose, nitrogen which would otherwise be wasted is retained. In regard to the quantity of amino acid administered, we have arbitrarily given 60 grams of amino acid daily to adults and 30 grams to children. This is more than the minimal basal requirement of protein estimated at 0.5 gram per kilogram but is probably less than the usual needs for postoperative, febrile, or acutely ill patients. Our practice has been to give 70 grams of glucose with each 30 grams of amino acid, this is a minimal amount of glucose to act properly as a sparer of protein. If the glucose is to serve as the only source of energy for the patient larger quantities become necessary.

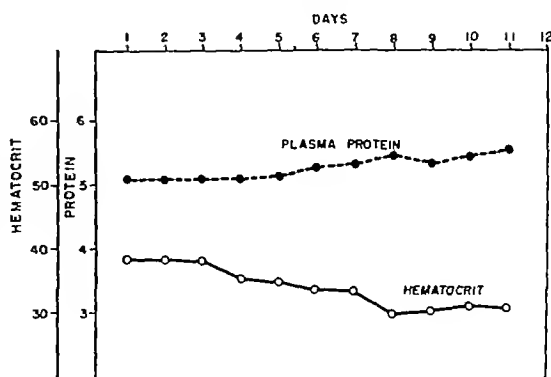


Fig 1 Chart showing the average daily plasma protein and the hematocrit in 7 afebrile postoperative patients each of whom received 60 grams of amino acid daily as their only source of nitrogen intake

In patients with fever, huge amounts of protein and glucose are necessary if the patient is to be kept in positive nitrogen balance. To prevent wasting of the body tissues in such patients, it may be necessary to give 2 or even more times the quantity of amino acids we have been giving.

#### SUMMARY

In 30 postoperative patients in whom feeding by mouth was impossible or unwise a solution containing glucose, vitamins, sodium chloride, and amino acids prepared by the enzymatic hydrolysis of casein was given intravenously as the only source of nourishment over an average period of 7 days.

The solution was found to be nontoxic. It could be administered quickly and easily. Although given intravenously at a rate of 30 grams of amino acid per hour it caused no significant reaction and appeared in the urine in insignificant amounts. In patients in whom excessive destruction of body tissue was not present evidences of plasma protein regeneration and of positive nitrogen balance were obtained.

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# SURGICAL GLOVES AND WOUND INFECTIONS

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UNTIL about 1890 all surgical operations were performed with bare hands. Holmes and Semmelweis were among the first to report that the hands served to carry the organisms of puerperal sepsis, a fact which has been demonstrated over and over again. Since the work of Halsted and others in the 1890 decade, the use of rubber gloves has become an essential part of surgical technique as a means of preventing wound infection. Their use is taken as a matter of routine and, as in all matters which become routine, this step in the performance of a surgical procedure may become subject to a certain amount of unintentional carelessness. It is our purpose in this paper to emphasize that, although we realize that they are only one of several possible sources of infection, perforated gloves are an important source of infection in clean surgical wounds.

## HISTORICAL

The infection of clean surgical wounds has been a major problem since the beginning of surgery. At first it was accepted as a normal risk of operation and the resulting suppuration was labeled "laudable pus." With the development of the germ theory of disease the presence of purulent exudate began to take on a new meaning. Surgeons began to realize that while phagocytosis was a normal phase of repair in infected wounds, healing was more rapid and the resulting scar was smaller if bacteria were eliminated from the wound. Since fermentation and putrefaction were brought about by bacteria present in the air, it was reasoned that this was the source of organisms infecting wounds. A wound was considered to be essentially an open culture tube with dead tissue as the substrate upon which bacteria could bring about fermentation and putrefaction. Since the air contained many bacteria capable of producing these changes and since the wound was exposed to the air, infection appeared to be a natural consequence. In order to prevent the development of such a condition, it was considered advisable to sterilize the air by spraying a suitable

disinfectant into it in the vicinity of operation. A solution of phenol was used for this purpose in most operating rooms. However, by about 1895 surgeons were being impressed with the importance of the skin as a possible source of organisms. As early as 1891 Welch demonstrated that staphylococci occurred in stitch abscesses. The importance of the skin as a source of infection was again emphasized when Robb and Ghriskey in 1892 showed that it contained both staphylococci and streptococci as common inhabitants. These findings have been confirmed by many others.

Park recognized the fact that infection could and probably did come from several sources. Among the possibilities he listed as "the principal sources of contact infection (1) skin and hair, (2) instruments, (3) sponges or their substitutes, (4) suture materials, (5) the hands of the surgeon and his assistants, (6) drainage materials, (7) dressing materials, (8) miscellaneous, e.g., drops of perspiration." He emphasized that the hands of all those concerned about the field of operation should be carefully disinfected. His concept of the importance of this procedure was vividly portrayed when he said, "cemeteries have been filled in time past by the septic hands of medical students." Robb and Ghriskey isolated staphylococci and streptococci from the stitches and wounds of all the patients so examined. Their insight into the importance of the skin as a source of organisms is portrayed by the statement "We have no sure and absolute method of rendering the field of operation entirely free from organisms, owing to the impracticability of destroying them in the superficial layers of the skin." No less an authority than McBurney stated in 1898 "My conclusion is that the real source of infection of a wound deliberately made by a careful surgeon who uses perfect materials and handles them perfectly is to be sought either in the skin of the patient or in the hands of those directly concerned in the operation." Also, "The writer does not claim that atmospheric dust is free from harmful germ life, but he does assert that, clinically, no evidence exists that such dust causes wound infection." Bovée commented in 1899 that "the air of the operating room is by no means free of pathogenic organisms, though this

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has probably been slightly exaggerated. He did not consider the introduction of rubber gloves alone sufficient to solve the problem, for he wrote "We have cleansed our hands just as carefully to use the gloves as was usual without them. This is necessary as gloves may accidentally be perforated during operation. The use of cloth gloves was discredited by Lockett when he said, 'The results of the above experiments seem to us to prove the absolute inefficiency of cotton gloves, both in their original state, and when purified they fail to prevent infection from the hands. While the use of gloves had already become routine in many places, leading surgeons continued to emphasize their importance after the turn of the century. Burford wrote that the operator's hands are the most dangerous sources of infection during operations is the most accepted view at least in America. It seems conclusive that the operator's hands are more dangerous to the patient than the patient's own skin. (p. 614) One having an infection on the fingers or the hand is not justified in operating while it lasts, even though the hands are covered by gloves, because of the risk of tearing the glove and leakage into the wound. Thomas considered gloves as having an indirect value to the surgeon when he facetiously remarked 'Gloves for unknown assistants are excellent, as the awe of the gloved hands prevents assistants from feeling impelled to feel the patient's pulse or open a door or window during the trying vicissitudes of any long operation. Brewer said that "by far the most important change in our technique which resulted from our bacteriological experiments was the adoption of the rubber gloves."

It was quite natural, therefore, that the interest should change from chemical sterilization of air to preoperative preparation of the hands of the surgeon and the skin of the patient. Many methods of skin sterilization were tried, but mercuric chloride appears to have been a favorite with great many. The majority of such techniques, however involved some combination of washing with soap rinsing with ether or alcohol, washing with bichloride of mercury and again rinsing with alcohol. Some operators also employed potassium permanganate and oxalic acid (12) In due time it was discovered that the chemical treatments employed were not as practical as had been believed, partly because the solutions were injurious to the hands, partly because they did not sterilize the surfaces in question.

In 1839 Halsted reported on the use of rubber gloves in surgery. Whether this was actually the

first application of such a technique may be debated but a literature search has failed to establish any other priority. Within a few years many types of gloves were being advocated for use in surgery. Some were silk, some were cotton, and others were leather some were rubber gloves without finger tips and some replaced the heavy finger tips with thin rubber finger cots. Because of the growing belief that passage of bacteria from the surgeon's hands to the wounds might take place through the cloth gloves, attempts were made to impregnate them with paraffin in 1862. Critical bacteriological tests, however showed this did not make them entirely impervious (9). There was, therefore a gradual adoption of rubber as the only safe operative glove to prevent wound infection.

By about 1900 rubber gloves were in common use in the better hospitals and private practice. However there were many claims of greatly reduced incidence of infections by using cloth gloves (cotton or silk). Since Da Costa (1858) had shown that instruments could be satisfactorily prepared for operative work by boiling, the method was automatically used for preparing the gloves, whether they were of rubber or cloth. Many surgeons, however preferred chemical sterilization, usually with bichloride of mercury. Curiously enough, in a given operating team it was customary for only part of the individuals to wear gloves. In some cases the surgeons wore the gloves, in others the assistants wore them. Bloodgood in 1896 (3) has been credited with being the first to require all assistants to wear gloves, but the practice was not uniformly adopted until some years later. McBurney claims Halsted required his assistants to use them as early as 1891 but the writings of the latter in 1891-1892 do not mention it. Many objected to gloves as they interfered with the tactile discrimination considered the surgeon's best asset.

The adoption of the rubber glove as a standard part of good surgery was a very slow process. While some were reluctantly accepting them on their merits, others were recognizing certain inherent dangers in their use. As early as 1899 Bovée pointed out that even with the use of sterile rubber gloves it was still necessary to cleanse the hands just as carefully as without them. He said, "This is necessary as gloves may accidentally be perforated during operation. He also emphasized that "the advantages of rubber gloves in surgery are first protection of patient against infection from operator's hands, and second, protection of operator's hands against infection from wounds.

Since the turn of the century, rubber gloves have gradually become an integral part of operative surgery in all reputable hospitals. The preoperative preparation of the hands has also continued as a part of the technique to lessen the hazard of infection from accidentally torn gloves as pointed out by Bovée. There has gradually developed the relatively uniform method of autoclave sterilization of the gloves in cloth packets. They are now usually wrapped individually and arranged for convenient aseptic manipulation by the washed hands of the one to wear them. Previously they were boiled in 5 per cent sodium bicarbonate solution. So long as the gloves remained intact, the chances of infecting a clean surgical wound were minimal. The importance of the glove today is certainly no less than in 1901 when Burford wrote "Do our wounds heal better and more quickly with gloves than without? I can answer most emphatically that they have done so in my experience. With McBurney, I can say that I believe there is as much difference in the healing of wounds made with and without rubber gloves as there is between healing where the new method (antiseptis and asepsis) is and is not used."

The use of rubber gloves has not completely eliminated worry from infection of clean wounds. While many surgeons deny such developments occur in their practice, Meleney has pointed out that an unbiased critical analysis of the records will usually surprise the surgeon in charge. However, he was of the opinion the infections came directly from the respiratory tracts of the operating personnel. The extensive work of Hart has also emphasized the air as a source of infection in clean operative wounds. On the other hand, Devenish and Mills definitely traced a series of wound infections to one surgeon who was persistently perforating his gloves during operation. Still more recently Hirschfeld has emphasized the hands of the operator as a source of infection.

It thus appears that, as far as wound infection is concerned, scientific thinking has completed a 75 year cycle. During the time of Lister emphasis was placed on air as being a source of infection. Emphasis was then (1890-1910) changed to the skin of the patient and the hands of the surgeon. In 1898 Mikulicz commented, "The rôle of the air in operative infections has been greatly exaggerated since the beginning, especially by Lister." With the more recent work of Meleney and Hart, resulting in the development of ultraviolet irradiation, emphasis has again been placed on the air. During the past few years chemical steriliza-

tion of the air by means of aerosols has been rapidly advancing. It appears now there is a definite need for sterilization of the hands since rubber gloves are easily and unknowingly perforated during operation.

#### EXPERIMENTAL

During the course of some investigations on the bacterial content of the air in the operating room, recently reported by Rice and associates it was decided to determine the incidence of perforated gloves used in the Central Surgery of the Indiana University Medical Center.

In order to be fair to the surgical staff it should be emphasized that the data recorded herewith were obtained on gloves used by the entire personnel including residents in training, internes, student nurses, and other assistants common to the operating rooms of most university hospitals. It is the opinion of the staff members who have had extensive experience in other hospitals that the frequency of wound infection here is not greater than that found in other teaching hospitals.

The gloves were tested by distending with water and observing for leaks. A more accurate but less convenient method was to distend the fingers with air with the glove immersed in water and observe for bubbles. It is our impression this method is more certain to detect very small holes. However, because of lack of time on the part of the help responsible for examining the gloves, the examinations were made with water. A record was kept of the total number of gloves used during each operation, the number found perforated, the nature of the operation and the name of the surgeon in charge. Data were kept for each operation, irrespective of the type or importance or the number of gloves used.

The significant findings from data collected over approximately 20 months are given in Table I.

TABLE I

Total number of operations (all kinds)	4,549
Number of operations with perforation of one glove or more	3,400
Per cent of operations with perforation of one glove or more	74.4
Total number of gloves used	35,763
Total number of gloves perforated	8,103
Per cent of gloves perforated	22.6

During the first 2 months the incidence of perforation was 32 per cent. There were two other separate months when the rate was higher than that given for the entire period, but these increases could not be traced to any individual. We



are not certain whether the reduced incidence after the first 3 months' observation is due to increased care on the part of the surgical staff or whether the coincidence is accidental. By the more accurate method of distending the gloves with air and immersing in water, we have examined 200 pairs of new unused gloves and have found none to be perforated.

We desired to obtain statistics on the incidence of wound infection among the patients operated upon in this surgery but consultation with the surgical staff emphasized the theoretical and practical difficulty in doing this. We believe no one factor can be used as a real index of minimal wound infection. Some patients develop a febrile reaction or leucocytosis or both without any grossly demonstrable evidence of wound infection. Others with obvious infection develop only a slight temperature or leucocytic reaction or both. To make cultures of the wounds would be meaningless since the surface of normal skin contains bacteria and the absence of growth on culture might mean either sterility or bacteriostasis due to the chemical used in preoperative preparation of the patient. It becomes a very difficult if not impossible task, therefore to determine a minimal infection. Because of this no record was made concerning the incidence of wound infection during the period in which the gloves were examined.

The work of Price, Hirschfeld, and others have shown that many thousands of bacteria are present on the average hand after the usual routine preoperative preparation. We have confirmed these findings in all essential details (unpublished). Perforation of a glove during operation therefore becomes very important. If one hand contained only 10,000 bacteria uniformly dis-

tributed over the surface 1 drop of perspiration in the finger tip could introduce a large number of bacteria. Furthermore, this is put directly into the wound when the perforated glove is on the hand of the surgeon. The practical importance of this is borne out by the work of Devenish and Mills.

#### SUMMARY

Data are presented showing the incidence of perforated gloves in the Central Surgery of the Indiana University Medical Center. The importance of perforated gloves as a possible source of infection of the clean surgical wound is emphasized. We believe some method of complete sterilization of the surface of the hands should be a part of modern surgery.

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# UNRELIABILITY OF BLOOD FINDINGS AS CRITERIA OF BURN SHOCK IN RABBITS

MILTON D. BOSSE, M.D., PAUL GROSS, M.D., and MARION L. HAGAN,  
Pittsburgh, Pennsylvania

It is generally accepted that hemoconcentration develops rapidly following extensive superficial burns of the skin. The degree and duration of the hemoconcentration have been considered very important prognostic signs of death or survival. The following experiments are presented because the results do not conform with those anticipated.

## METHOD

Seventy rabbits, each weighing about 2 kilograms, were given extensive superficial burns of the skin while under ether anesthesia. The majority of the rabbits were New Zealand white males, the rest were of other breeds and a few were females. Nearly all of the animals were burned either by immersing the distal two-thirds of the body in water at 65 degrees C for either 30 or 45 seconds, or by immersing the distal two-fifths of the body in water at 95 degrees C for either 5 or 10 seconds. In most cases the area burned was thoroughly soaked in a 40 degree C water bath immediately before and after burning. Ether anesthesia was of short duration and was only deep enough to prevent struggling. The animals were provided with amounts of food and water similar to that of normal stock rabbits. All preliminary red blood cell counts and other determinations on each animal were made on about 3.5 cubic centimeters of blood obtained from ear veins shortly before burning. Most of the determinations following the burn were made in each instance on about 3.5 cubic centimeters of blood obtained by cardiac puncture. Plasma proteins were determined by using the micro-Kjeldahl method for total nitrogen, subtracting the non-protein nitrogen, and multiplying the difference by 6.25. Rectal temperatures were recorded before and at intervals after burning. Hematocrit and clotting time determinations were also made. All surviving animals were sacrificed at intervals, up to 38 days following the burn. Autopsies were performed on practically all animals.

From the Western Pennsylvania Hospital Institute of Pathology, Ralph R. Mellon, M.D., director.  
Presented at the St. Louis meeting of the American Association of Pathologists and Bacteriologists, April 3, 1942.

## RESULTS

The mortality rate is shown in Figure 1. Fourteen animals, or 20 per cent, were dead 4 hours after the burn. Twenty-four more, or a total of 54 per cent, were dead within 24 hours. Twelve additional animals, or a total of 71 per cent, were dead within 3 days. Three other animals died 5, 7, and 10 days after the burn.

Differences in red blood cell counts after the burn compared to those before are expressed as per cent hemoconcentration in Figure 2. Wide variations in per cent hemoconcentration occurred at each period when red blood cell counts were made, but the majority of animals showed a mild to moderate increase at the 4 hour period after the burn. At 24 and 48 hours the red blood cell counts of the majority of animals had returned to normal, and at 72 hours the majority showed a decrease of 10 to 20 per cent below the normal.

Only 4 animals showed an increase in hemoconcentration of 40 per cent or more at the 4 hour period. One died within 24 hours, while the 3 others later showed a decrease in hemoconcentration. Two of these died during the next 24 hours, while the third survived.

Although 10 animals showed hemodilution at the 4 hour period, 8 of them died 5 in 24 hours and 3 in 2, 5, and 10 days. The latter 3 showed progressive increase in hemodilution.

Forty-two animals had hemoconcentrations between 0 and plus 39 per cent at the 4 hour period. Eighteen were dead within 24 hours. The 24 others later showed either hemodilution or decrease in hemoconcentration, but 9 of these were dead within 3 days and another died 7 days after the burn.

Differences in plasma protein levels after the burns compared to those before are expressed as per cent change in blood proteins in Figure 3. Wide variations in per cent change in blood proteins occurred at each period when determinations were made, but at the 4 hour period the majority of animals showed a decrease of 31 to 50 per cent. Curves for the later periods are not drawn on the graph because the number of determinations was small, but there is a trend toward return of the protein level to normal or above.

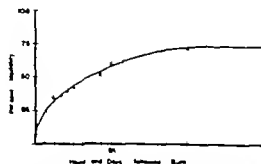


Fig. 1. Graph of mortality rate of rabbits following burn.

The 3 animals which showed little or no loss of plasma proteins at the 4 hour period nevertheless died within 24 hours after the burn.

One of the 9 animals that showed the most marked hypoproteinemia at the 4 hour period later showed a return to normal and 3 others showed improvement at the 24 hour period. However all 4 died within 48 hours after the burn.

Seven rabbits developed plasma protein levels above the normal at the 48 or 72 hour periods. Three of these died within 3 days after the burn.

Immediately after the burn there was a rise of several degrees in rectal temperature, followed within a short time by a drop of 4 to 5 degrees C. below the control temperature taken just before burning the animal. The animals were depressed. Ear veins had collapsed within 5 minutes after the burn in practically all cases, so that these veins either did not bleed at all when cut, or bled very poorly. Most of the rabbits on which determinations were made showed a considerable rise of nonprotein nitrogen of the blood following the burns. Hematocrit readings in general were parallel to the red blood cell counts. The clotting time of the blood was usually shortened from the

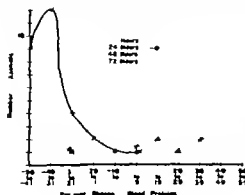


Fig. 3. Graph of changes in plasma following burn.

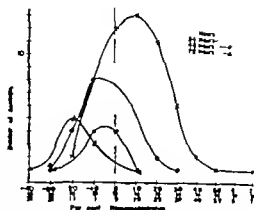


Fig. 2. Graph of hemococoncentration in rabbits following burn.

normal 4 minutes to 1 minute or less at the 4 hour period.

At autopsy no significant pathological changes were seen in the viscera in most cases, regardless of the time of death after the burns. Two animals died of cardiac tamponade following cardiac puncture. Some rabbits showed petechiae of serous surfaces, mild or moderate pulmonary congestion or hemorrhage and a few showed focal necrosis of the liver. Most of those that lived 12 hours or longer had a considerable accumulation of blood serum at the site of the burn.

#### OBSERVATIONS OF OTHERS

Underhill and associates found hemoconcentration occurring in most of their rabbits following light burns. The hemoconcentration was not maintained and in some animals it was quickly followed by dilution of the blood below the initial level. They also found some rabbits with hemodilution from the onset of shock. The tendency to hemodilution was explained by the hypothesis that the animals were able to draw upon the water reserves of the body to cause hemodilution either from the onset of the burn or following hemoconcentration. The animals in the experiments of Underhill and associates were admittedly only lightly burned over a relatively small area and the assumption was made that if the burns had been of sufficient gravity the animals would have been unable to compensate. Our experiments do not support this assumption inasmuch as hemodilution occurred in a significant number of fatally burned rabbits.

Moore (1) believes that the response of rabbits to shock-producing conditions such as burns is variable. The present theory of the mechanism

of shock as described by Moon (2) is supposed to apply to all animals which exhibit this phenomenon. The unreliability of blood findings as criteria of shock in the rabbit would appear to throw some doubt on the applicability of the theory to this animal.

#### SUMMARY

Seventy rabbits were burned by partial immersion in hot water while under ether anesthesia. Although the mortality rate was high, the majority of animals showed only mild or moderate hemoconcentration and the degree or duration of hemoconcentration were not accurate indications of the prognosis for survival or death. It was found in a number of rabbits which died that the hemoconcentration was quickly followed by either hemodilution or decrease in hemoconcentration and in several there was hemodilution from

the onset. Hypoproteinemia was more marked and occurred in most of the animals on which determinations were made, but some discrepancies were also encountered. Several animals with little or no hypoproteinemia died and several others, with earlier low plasma protein levels which subsequently improved or in some instances even returned to normal, also died. These results do not conform with those which have been reported on other animals.

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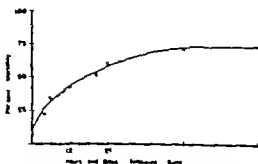


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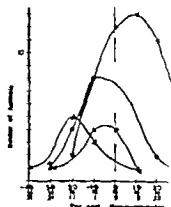


Fig. 2. Graph of hemoconcentration burn.

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At autopsy no significant changes were seen in the viscera in most of the time of death after the burn. Most died of cardiac tamponade or peritonitis. Some rabbits showed serous surfaces, mild or moderate granulation or hemorrhage, and a few necrosis of the liver. Most of the burns or longer had a considerable amount of blood serum at the site of the burn.

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Moore (1) believes that the response of rabbits to shock-producing conditions such as burns is variable. The present theory of the mechanism

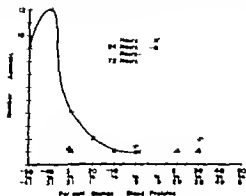


Fig. 3. Graph of changes in plasma following burn.

duodenum, or intestine of a postoperative patient. All too commonly the concept toward postoperative vomiting resembles that of the Duchess in *Alice in Wonderland* who says "speak harshly to your little boy, and beat him when he sneezes, he only does it to annoy, because he knows it teases." The patient who vomits usually does so to empty the stomach. Restriction of fluids and a lecture is not good treatment for postoperative gastric distention or vomiting. Aspiration of the stomach contents through a nasal catheter is much more pleasant and efficacious. Vomiting is hard, unpleasant work and one "up-heaval" will more than equal the hardship attendant upon the passage of a tube. There is no excuse for persistent postoperative vomiting, and he who permits it courts not only the displeasure of a tired, distressed sick patient but the likelihood of distention and dehydration with serious and possibly lethal results.

CHARLES G. JOHNSTON

## UNRECOGNIZED OBSTRUCTION AT THE VESICAL NECK

AND Moses was an hundred and twenty years old when he died: his eye was not dim, nor his natural force abated."<sup>1</sup> Brim<sup>2</sup> states that a correct literal translation of the second part of this passage from the Hebrew scripture should read "his secretions did not escape." Thus, the writer of the ancient scripture in a boasting manner declared to the world that the physical status of the aged patriarch was so nearly perfect that unlike other old men of his times Moses suffered no loss of vision from senile cataracts and did not dribble urine. The antiquity of the problem of urinary retention is, therefore, unquestionable according to Brim.

It is difficult to comprehend how it was possible for several thousand years to elapse without the appearance of even a partially successful solution of the problem of urinary retention, whereas within the space of one generation, even within the memory of men still living, an almost complete solution of the difficulty has been accomplished. The turn of the century witnessed much controversy and keen discussion among surgeons of that day as to the proper method of removal of the enlarged prostate gland for the purpose of relief of retention of urine. Shortly thereafter, the surgical procedures of perineal and suprapubic prostatectomy became well established. Although the transurethral method of operation on the prostate gland was among the first to be tried, it was not until the past decade that it was developed to such a point that it is now a standard surgical procedure, applicable in routine urological practice.

Of the present status of the subject of urinary retention in the male, this much can be said: in most cases obstruction at the neck of the bladder is readily recognized and the pathological condition is efficiently corrected by surgical treatment. Digital palpation of the prostate gland through the rectum and cystoscopic examination yield information which is sufficient in most cases to permit the making of an unqualified diagnosis of obstruction of the vesical neck caused by enlargement of the prostate gland or fibrotic contraction of the vesical neck.

If a casual survey is made of the modern problem of urinary retention, the pleasant picture is obtained of a large number of grateful patients well cared for. Closer examination, however, brings to attention the fact that there is also a small group of hapless patients suffering with urinary retention who still wander from physician to physician, seeking but not finding relief from their malady. These

<sup>1</sup>Deuteronomy 34:7 (King James translation)

<sup>2</sup>Brim C. J. *Medicine in the Bible*. New York: Froben Press, 1936 p 353

# EDITORIALS

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### GAS PAINS?

THE early recognition of ileus, whether occlusive or nonocclusive in type has long been recognized as being of importance in control of mortality from this condition. Treatment whether by early operation, intestinal intubation plus operation or intubation alone, is easier and more efficacious if begun early. The phenomena associated with persistent or marked distention frequently may be averted or at least minimized by early treatment.

Text material concerning ileus lists as cardinal signs, abdominal distention and obstipation. It is well to point out that these are not early signs of bowel obstruction. When distention is sufficiently marked as to be visibly or palpably obvious, the situation is no longer early as changes subsequent to distention have already taken place. Except in very thin persons distention of marked degree may be present without being obvious.

It is not unusual to hear the thought expressed that because a patient passes gas or

has a bowel movement, ileus is not possible present. It is not rare for patients with bowel obstruction to have some diarrhea, and passage of gas or feces is not uncommon. Partial obstruction, obstruction high in the gut, or segmental inactivity with hyperactivity in the lower bowel accounts for the passage of gas and feces long after the bowel is obstructed.

Diagnosis of ileus is made early by those alert to the possibility of its presence. Persistence of so called "gas pains" ought not be necessary to suggest ileus. The term "physiological ileus" ought not be allowed to cloud the fact that gas pains are not necessary in the majority of cases. Their presence is not due alone to the quiet imposed upon the intestine by the trauma of the operation but also by excessive gas in a reacting gut.

It has become customary indeed thought almost necessary for a vast array of laboratory studies to accompany a diagnosis of ileus. The expense of such studies, which are not likely to yield information of value in diagnosis, is frequently not considered. There is but one laboratory finding of importance in the diagnosis of ileus and that consists of a flat film of the abdomen. This is a simple painless laboratory procedure which yields rapid and definite data regarding the presence of gas in the small bowel long before abdominal distention is evident. The basic cost to the hospital of such study is less than that usually charged for ordinary blood chemical study and accordingly the use of films of the abdomen by portable machine if necessary ought to be encouraged.

There is still fear, apprehension, and distaste in some remote corners of medical practice to the passage of a tube into the stomach

# THE SURGEON'S LIBRARY

## REVIEWS OF NEW BOOKS

THE excellent monograph on *The Treatment of Burns*<sup>1</sup> by Harkins is published at a most appropriate time, as the subject is one of importance to both the industrial and military surgeon. It has brought up to date the world's literature on the subject of treatment of burns.

In offering a word of criticism one wonders if the younger surgeon or student, after reading the volume, would be able to plan and carry out an effective method of treating a burned patient because so many different methods are described as almost to cause confusion.

One serious omission, in the reviewer's judgment, is the lack of emphasis, almost of mention, of the importance of primary cleansing of the large open wound and of preventing subsequent infection. If we have not yet become aware of the importance of masking the patient and the personnel during treatment, early and late, of large open wounds, then we shall continue to have serious infections of patients with burns. The evidence regarding infection has been well presented in Chapters 9 and 10 but the obvious conclusions are omitted.

In the chapters on "General and Local Care" of the burns the question of cleansing of the open wound is only briefly suggested by reference to the "Tschmarke method" under the heading of débridement. Certainly the beginner in surgery, after reading these chapters, would fail to realize that conversion of the contaminated wound into a clean wound is a primary principle in the treatment of a burned surface.

HARVEY ALLEN

THE valuable and practical book *Métodos Modernos de Amputação*<sup>2</sup> is one of the best presentations of amputations we have seen. The material is based on the author's large experience, study of postmortem material, and thoughtful consideration of some five hundred articles in the surgical literature of South and North America, England, and continental Europe.

The first and second chapters deal with general considerations, including discussions of optimal levels of amputations and technique. In the upper extremity the optimal levels are shown to be different in the intellectual man and in the laboring man. The principles of dealing with the skin, aponeurosis, muscle, bone, cartilage, synovia, nerves, and vessels

are fully presented. The third chapter discusses the indications for amputation.

The fourth and fifth chapters are taken up with detailed descriptions of individual amputations. This section is made vivid and instructive by a wealth of splendid drawings by José Gonçalves Filho. For teaching value, these drawings far exceed photographs or simple line diagrams, and they deserve highest commendation.

The final chapter is a practical and well illustrated description of the various prostheses suitable for different types of amputations.

FREDERICK CHRISTOPHER

A VERY definite need of a practical book dealing with less extensive surgical procedures is filled by Ferguson's *Surgery of the Ambulatory Patient*<sup>3</sup>. The teaching of surgery in most medical schools is concentrated on major hospital procedures and often too little attention is paid to the care of so called minor surgery. This lack is exhibited by the confusion of most internes when they begin their services in hospital out-patient departments. As is emphasized by the author, surgical procedures which can be performed in a physician's office or hospital dispensary are very numerous. Many of them require as much diagnostic skill, surgical ability and judgment, and meticulous care as major hospital procedures. Poorly done, they may produce lasting disabilities. Many surgeons prefer to confine all of their operative work to hospital patients and will hospitalize some who could as well be handled in the office. This has some advantage for the surgeon but the added expense and loss of time may be an unnecessary burden to the patient.

The extensive experience of the author in dealing with surgical lesions of ambulatory patients has made him familiar with this field. He has gone into detail to supply all necessary information for the satisfactory conduct of office surgery. Office equipment and preparation is described minutely. The advantages of various forms of anesthesia and methods of administration are clearly outlined and illustrated. Preoperative preparation, dressings and bandages, and subsequent care are explained. The book is divided into three main sections: one describing the nature and care of typical lesions, the second, devoted to regional surgery, and the third, to fractures and dislocations. Many contributions have been made to the book by associates of the author which have added authoritative information.

<sup>1</sup>*SURGERY OF THE AMBULATORY PATIENT* By L. Kraeger Ferguson, A.B. M.D. F.A.C.S. Philadelphia London and Montreal J. B. Lippincott Co. 1942

<sup>2</sup>*MÉTODOS MODERNOS DE AMPUTAÇÃO* By Edmundo Vasconcelos, Ph.D. F.A.C.S. Springfield Ill., and Baltimore, Md. Charles C. Thomas 1942

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in special fields. Anatomical drawings of the body and skeleton with page listings of lesions of each part make a very practical index.

In general, I think the book is excellent and practical guide for office and dispensary surgery. Perhaps more emphasis could be placed upon the dangers of surgery of patients not hospitalized. Many procedures are included which are quite major and which should be done on ambulatory patients only under most favorable conditions and when hospitalization is impracticable.

CHARLES B. PUTZOW

THE basic organization of the medical department is considered in detail in Lasher's *Industrial Surgery*, which is a well-written book based on an extensive industrial practice. The book should be of great value to the host of small industries in which little is known of the medical department and how to go about organizing it.

The present national emergency has brought out the fact that the industrial surgeon is by far the most valuable individual at home to care for the workman and in the field to care for our fighting forces. It is foretold that in the very near future large universities will establish special departments dealing with industrial medicine and surgery to give previously ignored groups adequate skilled training.

One hundred and sixty-eight infections among 30,019 fresh wounds is a rather high number. The high percentage of infections ties in well with the statement of policy expressed on page 74 that small compound wounds are swabbed with tincture of iodine and covered with sterile gauze and left undisturbed *USLESS*.

The experience of the author and the analysis of malingering is well dealt with. Fractures as a whole are well handled. Injuries to the hip, the author is of the opinion that the Whitman closed reduction compares favorably with those obtained by other methods.

The recognition that dental services be rendered by the industrial medical department is to be highly commended in the form of educational activities, diagnostic service, prophylactic care, emergency treatment, and operative dentistry limited to simple extractions and fillings.

The subject of electrical shock is handled especially well when the author states that as long as eight hours may be required before the paralyzed respiratory center responds to treatment.

The approach to the femoral hernia through an inguinal incision is to be commended.

The author believes that frankness, impartiality, frequent consultations and repeated x-rays (often shown to the patients and explained to them) will go far in gaining the whole-hearted co-operation of the workman.

R. J. BERRYETT

AN attempt is made in Schaffer's *Pediatric Gynecology* to combine into one small volume a list of subjects from the embryology of the female pelvis to the medicolegal aspects involved after the pelvic organs have performed their mature function. The management and psychological approach to the child plus a description of the preferred technique in examining small apprehensive patients is stressed throughout the volume. It is a combination of good common sense plus a keen insight into the mental reactions of children. The discussion in places is a bit vague and not as descriptive as the subject justifies.

Common but distressing problems, such as diaper rash, are given decent treatment. Many practical points are covered under the section on vaginitis; the proper technique in taking a vaginal smear and its inadequacy in making diagnosis; the value of cultural methods in the diagnosis of gonorrheal infections; the insistence that acutely ill children with incidental gonorrheal can be safely admitted to general hospitals if proper isolation technique is carried out; the condemnation of child-caring institutions, and the recommendation of foster homes for the care of gonorrheal vaginitis. These numerous points are concluded with description of the simplified treatment for gonorrheal vaginitis, emphasizing that, at the present time, sulfathiazole is the drug of choice.

In the section on hormone therapy the author sounds much needed note of warning against their promiscuous use; a very unstable period is a child's life. The usual and many times unsuccessful treatment of enuresis is covered; also the questionable procedure of trying to train an infant to toilet habits before it is able to sit up is advocated. A rather large section is devoted to the social service medicolegal problems that arise in dealing with this subject. This book will be of value in making one consider the gynecological problems of children in their entirety.

L. MARTIN HARRIS

THE 6th edition of one of the most popular British textbooks of medicine has recently been released. The book is written on the multiple author plan by an unusually well-chosen and eminent group of English authors. The editor has had the foresight to limit the number of contributors so that for the most part each of the sections has been written by a single individual. Thus many of the objections to a multiple author textbook of medicine are overcome and yet most of the advantages are maintained.

The text is in one volume and includes sections on dermatology, tropical medicine, and psychological medicine. In spite of the 2000 odd pages it is only slightly thicker than most one volume medical textbooks, thanks to especially thin paper.

PERMANENT GYNECOLOGY. By Gmelin C. Schaffer, A.B. M.D. Chicago: The Year Book Publishers, Inc. 1942.  
SECTION OF THE PRACTICE OF MEDICINE. By various authors. Edited by Frederick W. Price, M.D. C.M. F. C.F. I. (L.A.) 6th ed. London: Oxford University Press, 1942.

ESSENTIAL SURGERY: PRINCIPLES, PROBLEMS, AND PRACTICE. By Wm. E. Lasher, M.D. F.A.C.S. New York and London: Paul B. Hoeber, Inc. 1942.

The subject matter is treated in a conventional manner with emphasis on those things of a practical nature. The discussion of etiology and pathology and theoretical material is rather brief. In this edition the text has been brought entirely up to date and thoroughly revised. In the reviewer's opinion this is one of the best single volume texts of medicine available.

RICHARD B. CAPPS

THE history of and indication and technique for the operation of vaginal hysterectomy are dealt with in Kennedy and Campbell's *Vaginal Hysterectomy*.<sup>1</sup> The historical data are very complete and bring the reader up to the present time. The indications for vaginal hysterectomy and the surgical technique are exhaustively set forth, and the advantages of the vaginal operation are contrasted with those of the abdominal procedure in an attempt to evaluate the merits of each operation in certain types of cases.

The vaginal hysterectomy operation is contrasted with the use of x-ray and radium in treatment of malignant disease of the uterus. The use of the cautery in connection with vaginal hysterectomy is discussed.

Considerable space is given to the interrelationship between the ovary and the uterus as regards hormonal stimulation, and the bearing this subject has on hysterectomy is freely discussed.

The postoperative complications which may develop are clearly set forth and discussed, and postoperative treatment is outlined.

Dr Kennedy presents a series of illustrations showing in detail vaginal hysterectomy by the clamp method. Each illustration has an exhaustive legend and sets forth in detail the steps of the operation shown in the accompanying full page drawing. The pathology of the various conditions which indicate vaginal hysterectomy as well as the steps in the operative procedure are illustrated. Associated pathological conditions, such as cystocele and rectocele, are also discussed and the steps in the operation for their cure are carefully outlined.

Dr Campbell in Part 3 takes up the technique of vaginal hysterectomy by the ligature method. He describes at length the factors entering into the production of uterine procidentia, laying special emphasis on the anatomy. Preoperative and postoperative care together with indications for the operation are thoroughly discussed. Complications immediate and remote are also described, and appropriate suggestions are offered for the care of complications which may occur. This section is supplemented by a series of 21 halftone illustrations which depict removal of the uterus by the ligature method and many important associated anatomical relationships between the

genitalia and other pelvic and abdominal structures. Many important points in diagnosis and technique are shown and stressed by the author.

This book is well written by two masters of the technique which they have described. It clearly sets forth the advantages of each method and leaves the reader free to make his choice of operation. Many valuable suggestions may be gleaned from careful reading of this treatise by the inexperienced surgeon as well as by men who are familiar with general surgery, and also those who have had considerable experience in this particular field. The type is exceptionally clear and readable and the paper is excellent. At a time when vaginal hysterectomy is enjoying more and more popularity, it is a book that every surgeon can well afford to read and digest to help improve his technique in respect to this operation.

F. H. FALLS

IN an interestingly written book of 450 pages the author of *Surgical Physiology*,<sup>2</sup> briefly summarizes the more important aspects of physiology as they concern the surgeon. The organ systems are each covered in separate chapters. The material covered is hardly extensive enough for a reference work as the author did not intend that it should serve such a purpose. For this reason, however, it is open to the criticism of all such concise reviews in that some sacrifice of accuracy and completeness must be made. The recent literature is fairly adequately if slightly uncritically reviewed.

Collecting such an amount of material into a single volume was a tremendous task. The production of a readable and stimulating book on a subject with as extensive a literature as physiology as it applies to surgery is a real contribution, and the author is to be congratulated.

THOMAS C. DOUGLASS

THE book *Pathology of the Oral Cavity*,<sup>3</sup> by Lester R. Cahn is a well prepared treatise on the common pathological conditions of the oral cavity, with excellent histopathological illustrations. Many good clinical photographs and x-ray films add to the practical value of the text, although clinical diagnosis and treatment are generally omitted.

The chapter on cysts and tumors of the jaw bones and on the histology and pathology of the soft tissues are very well done. The chapter on diseases of the hard structure of the teeth, including dental caries, might well have been omitted, as well as that on pyorrhea. As a concise and pertinent text on histopathology of oral lesions, it is an addition to the literature and one which is conveniently arranged for practical use.

CHARLES W. FREEMAN

<sup>1</sup>*VAGINAL HYSTERECTOMY*. By James William Kennedy, M.D., F.A.C.S., and Archibald Donald Campbell, M.D., C.M., F.R.C.S. (C). F.R.C.O.G. F.A.C.S. Philadelphia: F. A. Davis Co. 1942.

<sup>2</sup>*SURGICAL PHYSIOLOGY*. By Joseph Nash, M.D., Springfield, Ill., and Baltimore, Md.; Charles C. Thomas, 1942.

<sup>3</sup>*PATHOLOGY OF THE ORAL CAVITY*. By Lester Richard Cahn, D.D.S., Baltimore: Williams & Wilkins Co. 1941.

# AMERICAN COLLEGE OF SURGEONS

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## 1942 CLINICAL CONGRESS CANCELLED

THE annual Clinical Congress of the American College of Surgeons, which was scheduled to be held in Cleveland November 17 to 20, 1942 was cancelled by the Board of Regents of the College at a meeting held in Chicago Wednesday October 14. Motivated primarily by patriotism the regents were influenced by the present conditions surrounding the general war program which have led to a greater burden on the members of the surgical profession in their local communities as a result of the large proportion of the profession which is serving with the armed forces. The regents by this action took cognizance of the desire of the profession to do nothing which would interfere with the successful prosecution of the war program such as would be caused by temporary absence of its members

from civilian duties during the period of the Congress, embarrassment of the transportation system, and interference with the work of the local profession in Cleveland in preparations and presentations incident to such a meeting.

At the annual meeting of the Board of Regents, which will be held in December fellowship in the College will be conferred in absentia on the class of initiates of 1942 as there will be no convocation exercises. At the same time the list of hospitals, cancer clinics, medical services in industry hospitals conducting programs of graduate training in surgery and medical motion pictures, that meet the College standards will be approved and later published.

All present officers, governors, regents, and standing committees will continue in office.

# SURGERY

## GYNECOLOGY AND OBSTETRICS

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### NEW OPERATIVE TECHNIQUES IN THE MANAGEMENT OF BOWEL OBSTRUCTION

(1) Aseptic Decompressive Suction Enterotomy, (2) Aseptic Enterotomy  
for Removal of Obstructing Gall Stone, and (3) Operative  
Correction of Nonrotation

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THE past decade has witnessed a general decline in the mortality of intestinal obstruction. In the Massachusetts General Hospital, in Boston, there has been a keen and lively interest in the subject over a period of more than 40 years. A recent study by McKittrick and Sarris (1940), from the same institution, showed that for the first time in 40 years, a definite lowering of the mortality of acute intestinal obstruction has come about. This unique experience of the Boston group cannot be duplicated perhaps in any American hospital in length or intensity of interest in the subject. Yet, the more recent experience of the staff of the Massachusetts General Hospital with acute intestinal obstruction appears to typify the general improvement, which has become manifest

throughout our country, in the management of the problem of bowel obstruction.

In the opinion of this writer, this noticeable general improvement has come about essentially by virtue of two factors, viz (1) better understanding of the effects of obstruction, including more general adoption of the mechanistic conception of the ill effects of obstruction, and (2) introduction of the conservative plan of achieving relief of intestinal distention by suction applied to indwelling duodenal tube.

#### FACTORS ACCOUNTABLE FOR MORTALITY

An analysis of the factors contributing to the residual mortality of obstruction indicates that two items are responsible largely, viz (1) strangulating obstructions and (2) persistent distention. In a sense, it may be said, this mortality is owing in part to the shortcomings of the conservative suction treatment, an agency which has had an important part in the reduction of the mortality of obstruction. In the instance of strangulating obstructions, no indication exists for attempting to treat such patients by suction. Yet, most clinics in

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which suction has been employed in the management of intestinal obstruction have suffered the embarrassment humiliation, and tragedy of discovering too late on occasions, that their efforts of attempting to effect conservative decompression were being misapplied to patients with strangulating obstruction exhibiting every indication for early surgical intervention. This occurrence has been responsible for 4 deaths in this clinic during the 12 year period, during which time suction has been employed as a therapeutic expedient in the management of acute intestinal obstruction that is, 4 patients came to autopsy without recourse to operative intervention. There have been other circumstances undoubtedly not so readily assessable, in which less prolonged delays with conservative management in strangulating obstructions were, at least partially responsible for additional fatalities. This delay in supplanting conservative with radical therapy is due largely obviously to the difficulty in identifying correctly instances of strangulating obstruction.

The conservative plan of management accepts another risk in simple obstruction in that decompression may not be achieved by suction and recourse may have to be had to operation as a last resort. This risk is less hazardous to the individual than is delay in strangulating obstruction, for even in late cases of simple obstruction with considerable distention a well planned and carefully executed operation may still salvage the situation. Yet, it is not to be denied that such delays occur more frequently than they should. And in the total mortality of obstruction this factor of failure to deal adequately with distention by conservative means, looms large as an important item.

It should also be said that no therapeutic measure can match the low mortality of the

suction cases in that group in which conservative decompression is the only direct therapeutic agent invoked. The pity of it is that suction management is not uniformly successful. In the first series of cases of acute obstruction treated by conservative decompression reported from this clinic in 1933, by Paine and the writer (33) the mortality was only 5 per cent. In the next report, made in 1939 (34) the mortality in the suction group was 6 per cent. In the next series, reviewed by Dennis and Brown 1942 (5) from this clinic the mortality in the suction group (32 cases) was zero. Yet as indicated, in all these reports and as has been pointed out an analysis of that group alone fails to tell the whole story. For it is possible that a patient start out as a bona fide suction case and show up ultimately in the mortality columns of operative procedures.

There are other factors which contribute to the existing residual mortality of bowel obstruction. Some obstructions particularly atresia of the newborn and strangulated hernial hernias in obese patients with poor cardiac reserve are inherently difficult to deal with others, such as a mesenteric thrombosis and the ileus of peritonitis, will always carry formidable risks. Some of the factors involved in the obstruction problem appear to be uncontrollable. It is to be remembered, however that late recognition of obstruction and delay in hospital may make a very difficult problem out of an obstructive agency which may have been dealt with very simply in the beginning.

Yet, if the two items discussed at some length—(1) strangulations and (2) persistent great distentions of the small intestine—could be dealt with in a more consistently successful manner than at present, the existing residual mortality of bowel obstruction would fall sharply. Whereas, the current mortalities of 12 to 20 per cent, acknowledged by most clinics professing an especial interest in the bowel obstruction problem, are due in part to difficulties hedging about the management of trying cases, yet, as has been pointed out, there is a mortality of treatment—a factor which must be recognized as such, if further reduction in the mortality of bowel obstruction is to come about.

<sup>1</sup>Two of these patients were listed in an earlier report (33a) Group IA, Cases 7 Univ. Hosp. Va. 440453, and 8 Univ. Hosp. Va. 440454. Since then additional cases occurred, it is only fair to say that, in one of these, Mrs. R. M. Univ. Hosp. Va. 440455, operation had been done for diabetic gangrene. When abdominal pain developed during convalescence and later, when it was believed that dissecting aneurysm of the aorta was present, suction was employed to combat distention. Autopsy disclosed strangulating obstruction due to an adhesive band. In the other, Mr. J. K., Univ. Hosp. Va. 440456, herniation of loops of small intestine occurred around colonoscopy the true situation not being recognized until autopsy.

GENERAL PLAN OF MANAGEMENT IN  
THIS CLINIC

Since the introduction of suction (1931) in the management of acute mechanical intestinal obstruction, the general plan of management in this clinic has remained largely the same. It was recognized in the beginning that, there are two *absolute* contraindications to employment of suction, viz., (1) strangulating obstructions, and (2) obstruction of the colon with great distention (large diameter of the distended colon, as visualized on the scout x-ray film of the abdomen). Both these conditions constitute *absolute* indications for early operative intervention. It is important that suction not be applied as the sole direct therapeutic attack upon the obstruction in instances in which the obstructing mechanism persists. It is in mechanical obstructions of the small intestine, obviously, that suction plays an important rôle as a single direct therapeutic expedient. Definition of the indications for suction in a number of cases can not, therefore, be stated positively, that is, in the larger number of instances of simple obstruction of the small intestine, the indications for the continued use of suction are relative. Without trial, one cannot know in a given instance, whether suction will succeed or not, in partial obstructions suction is almost uniformly successful. The trial period must be reasonable and tempered by the knowledge that a persisting type of obstruction may be present, such as a gall stone, enteric intussusception, carcinomatous stricture or, more frequently, a tightly constrictive adhesive band which may cut right into the lumen of the bowel. It is to be admitted freely that all patients with distention are improved by a temporary period of suction. Yet, it is important not to confound seeming improvement with complete relief of the obstruction. When a trial with suction fails to re-establish intestinal continuity early it is essential not to procrastinate until it is too late. A timely decision is of more than ordinary importance.

The long balloon-tipped tube of Miller and Abbott has superseded the ordinary indwelling duodenal tube, with multiple perforations, in this clinic in the management of all cases of

obstruction. Abbott's recent suggestion of employing a wire stylet to facilitate entry of the tube into the duodenum affords real promise of affecting quicker decompression in a number of cases.

In the main, however, in this clinic we are inclining to earlier operative intervention in those cases in which a reasonable trial with suction proves ineffectual, at the same time, by concentration of the general management of patients with obstruction in the hands of a few experienced observers, efforts have been redoubled to identify instances of strangulating obstruction on arrival of the patient at the clinic.

During the past 2 years, 53 patients with 57 acute obstructions have been treated in this clinic (small bowel obstructions of all varieties). There were 6 deaths, a patient mortality of 11.3 per cent and a case mortality of 10.5 per cent. During the past year, 27 patients with acute obstruction of the small intestine came under observation. There were 2 deaths, a mortality of 7.4 per cent. This accomplishment is a better record than has ever been achieved with the bowel obstruction problem in this clinic.

## STRANGULATING OBSTRUCTIONS

Within the past year, 9 consecutive strangulating obstructions have been identified in this clinic and submitted to as early operation as circumstances would permit. These cases embrace the usual strangulations from a gangrenous intussusception in an infant of 2.5 months to a woman of 75 years with an extensive mesenteric thrombosis. Primary resection, with the use of the closed end-to-end anastomosis and with approximately 2 to 4 grams of sulfathiazole powder being sprinkled about the suture (in adults) was done in all instances. There was no mortality. My associate Dr. Clarence Dennis, together with senior house officers, was responsible for this unusual accomplishment.<sup>1</sup> This experience bespeaks (1) timely recognition of strangulating obstruction, and (2) the safety, in skilled hands, of the closed oblique end-to-end intestinal anastomosis under trying circumstances.

<sup>1</sup> This series now has grown to 12 consecutive successful primary resections for nonviable strangulated intestine.

## THE CRITERIA OF RECOGNITION OF OBSTRUCTION

The standard guides set up to aid in the identification of various types of bowel obstruction have been described on numerous occasions and will not be repeated here. Briefly it may be said the initial objective is to determine (1) whether obstruction is present, (2) whether the obstruction is simple or strangulating in character and (3) whether the obstruction involves the small intestine or the colon.

A surgical staff that has become "obstruction minded" and has schooled itself in the simple rules of detection and differentiation of the various types of intestinal obstruction will not make many serious errors in diagnosis. The following items are important in such a scheme: (1) concentration of the management of all cases in a few hands, necessitating continued interest of a few seasoned observers as active or consulting participants; (2) recognition of the importance of signs of peritoneal irritation in the detection of strangulating obstructions; (3) an understanding of how the ileocecal valve and sphincter affect the manifestations of obstruction; (4) with particular reference to (a) vomiting, (b) its character as well as the nature of the material aspirated by an indwelling duodenal tube, and (c) the character of the distention as revealed by an x-ray film; (4) complete fusion and integration of clinical and x-ray evidence recognizing that the diagnosis of intestinal obstruction is essentially a clinical and not a primary roentgenologic problem.

The chief weakness in the recognition of obstruction relates to a lack of *absolute* differential characters by which strangulating obstructions may be identified with *definiteness*. In the main, the best criteria in the writer's experience have been: (1) the history establishing the presence of obstruction (copious vomiting in obstruction of the small bowel, accompanied by recurrent gas pains) and (2) the presence of rebound tenderness or demonstration of an intraperitoneal mass, suggesting a strangulating obstruction. High grades of leucocytosis, or an increasing leucocyte count as suggested by McKittrick and Sarris (15) in the experience of this clinic have not been

characteristic or particularly helpful in the recognition of strangulating obstructions. The writer has pointed out elsewhere that strangulating obstructions may be accompanied occasionally by little or no distention (32).

In recent case Mrs. H. S., aged 55 years, University Hospital, No. 63288, with a 60 hour story of illness, the leucocyte count was 12,600. There was no definite evidence of *intestinal obstruction* demonstrable after admission to hospital. Yet, the story of gas pains and profuse regurgitant vomiting spoke eloquently for obstruction. Rebound tenderness and the detection of mass suggested the presence of a strangulating ovarian cyst or bowel, despite the absence of clinical distention. Even x-ray evidence of distention was missing, only a small amount of gas being distinguishable in a single ileal loop. A strangulated non-viable ileal segment, necessitating primary resection and closed anastomosis, was found at operation (Dr. C. Dennis). The patient made a satisfactory convalescence. Only the signs of peritoneal irritation indicated the necessity for operative intervention.

## THE PLAN OF CONSISTENT EARLY OPERATION FOR OBSTRUCTION

Prior to the introduction of suction in the management of intestinal obstructions of mechanical origin everyone conceded freely the necessity of early operative intervention. With the advent of conservative decompression a trial with suction in suitable cases became the rule. Lately McKittrick (14, 1931) has advocated and practiced early operative intervention in all cases in which the obstruction is less than 24 hours in duration after instituting suction, and relieving dehydration and dechlorination. McKittrick's results justify fully his manner of dealing with the problem. The only objection which could be raised justifiably would be the question of whether some of these operations would have been unnecessary with a longer trial period of suction. Nevertheless, if fewer deaths result with McKittrick's proposed scheme of return to consistent early operative intervention, it will become the preferred mode of dealing with the obstruction problem.

## ASEPTIC DECOMPRESSIVE SUCTION ENTEROTOMY

I have been at pains to point out, on previous occasions, the great importance of accomplishing aseptic decompressions at operation *without visible spillage* (enterostomy—26, 1931).

and transverse colostomy—28, 1937) Granted preservation of viability and normal permeability of the bowel wall, even in the late cases with large distentions a decompressive enterostomy or a colostomy can be done with minimal mortality. The risk approaches zero, in direct proportion to the success with which aseptic decompression without visible evidence of spillage can be done. The technique of performing these procedures is illustrated in Figure 1.

The writer has voiced opposition to the Monks-Movvihan scheme of intestinal evacuation, in the belief that an enterostomy would accomplish essentially what that procedure professes to do and at lesser risk. However, the limitations of "blind enterostomy" are obvious in the unhappy ending of the patient whose history is related below. Such an occurrence indicated the necessity for developing some means of dealing adequately occasionally with the factor of distention at operation.

**Summary of case history.** A patient, with a 5 day simple obstruction before entry, was treated conservatively for 4 days at which time enterostomy was done. The patient died 9 days later of peritonitis, as a result of an injury of the bowel wall occasioned by compression by a dense adhesive band. Aseptic evacuation of the content of the distended bowel, permitting visualization and division of the adhesive band, would undoubtedly have averted this occurrence.

C. W., Univ. Hosp. No. 654754, male, aged 50 years. The patient was admitted to the hospital December 22, 1936, with a story of crampy abdominal pain and vomiting of 5 days' duration. There had been no antecedent operation. The patient stated that he had been struck in the abdomen by a base ball many years previously. Eight years ago he had suffered an attack much like the present one. An x-ray film showed considerable distention of many loops of small intestine. No gas being visualized in the colon, the obstruction was believed to be fairly complete in nature. Suction was applied to an indwelling duodenal tube and the next day the distention on the x-ray films appeared to be less prominent. The two following days, the character of the distention remained essentially the same. Gas and fluid, in considerable amounts, were aspirated by the indwelling tube each day, the tube failed to enter the duodenum, however. On December 26, 1936, exploration appeared to be in order, because of failure to effect decompression by conservative means.

Operation was performed under novocain infiltration and a small amount of ethylene was given also. A low incision was made over the right rectus muscle. There was considerable clear, free fluid in the peritoneal cavity (transudate). Several collapsed segments of small intestine came into view suggesting, definitely, that the obstruction was in the small intestine. A suggestion had been made prior to operation that the patient might have a carcinoma of the ileocecal valve. No mass was made out, the intestine was very much distended. The nature of the obstructing mechanism was not made out. Deep in the abdomen, on the posterior abdominal wall, there seemed, to the touch, to be a small band kinking a loop of bowel. Because of the great distention, however, it could not be visualized. In the absence of a strangulating obstruction, it appeared that an enterostomy would take care of the situation adequately. An aseptic enterostomy, after the general plan of Witzel, was made without incident (operating time 1 hour). Gas and fluid drained freely from the catheter after operation, and the distention, as viewed by x-ray films, improved, gas made its appearance in the colon also. However, fever and a hurried pulse developed, and the patient died on January 4, 1937, 9 days after the operation.

Autopsy disclosed a dense adhesive band 3 millimeters thick and 15 centimeters in length, imprisoning a loop of small intestine 16 inches beyond the site of enterostomy. There was diffuse peritonitis present which had its origin apparently from the site at which adhesive band and gut wall were fused. Colon bacillus was found in the exudate.

During the past year, a scheme of dealing with large distentions of the small intestine at operation has been evolved. The principle of the procedure is essentially that of the Monks operation. Yet, the refinements in the procedure described herein occasion (1) less trauma to the bowel, in that considerably less manipulation of the distended bowel is necessary, (2) further, the procedure, described herewith, presents reasonable assurance of being performed aseptically and without spillage, the *sine qua non* of a successful operative decompression. The instrument built along the lines of an empyema evacuating trochar is depicted in Figure 2. The manipulation of the instrument is described in the caption. To date, the method has been used but once,<sup>1</sup> in

<sup>1</sup>Since this paper was written aseptic decompressive suction enterostomy has been employed with great satisfaction in several additional late cases of small bowel obstruction great distention being present in each instance. In this clinic this method of emptying a distended bowel at operation, has come to be routine practice in all late cases of simple presence of strangulated nonviable bowel. The method is employed in the early to achieve decompression of the proximal distended loop before resection and closed anastomosis are undertaken. In a few of these aseptic decompressive enterotomies as much as 2,000 cubic centimeters of gas and fluid have been aspirated.



the trying situation to be described. It is unlikely that any other method of dealing with the distention and the obstructive mechanism could have been accomplished without assuming far greater risks (save operation at the outset). It is obvious that the method will not have the same range of usefulness as conservative decompression or enterostomy.<sup>1</sup> Yet, there are instances of large distentions in which it is mandatory that the nature of the obstructing mechanism be determined. In a situation like the following one cannot ascertain the exact manner in which the bowel is obstructed, unless the reaches of the intestine in the immediate proximity of the obstruction are evacuated.

**Summary of case history.** A patient, age 50, with a 7 day story of obstruction failed to respond to conservative treatment. At operation, aseptic decompressive suction enterotomy permitted evacuation of 500 cubic centimeters of fluid and gas and visualization of the mechanism of obstruction: an adhesive band had amputated the bowel, a temporary seal being effected with fibrin. The procedure adapted itself very well to the management of a difficult problem.

Mrs. L. B., aged 50 years, Univ. Hosp. No. 7538, admitted to the hospital December 9, 1941. This patient the wife of an army officer had been ill for 7 days (since December 94) prior to admission here with nausea, vomiting, and crampy abdominal pain. The vomiting was greenish in character. She was hospitalized at the Military Hospital at Fort Snelling. Section was opened to an indwelling duodenal tube and the pain subsided, but the existent distention did not subside. She was transferred to the University Hospital on December 9, 1941. The contractions of the intestine could be seen and felt with the hand. The palpable peristalsis suggested that a carcinoma of the small intestine might be present. A fairly high grade of intestinal distention was observed on an x-ray film. There was no abdominal tenderness, and it was believed that the obstruction was simple in character. An attempt was made to pass a Miller Abbott tube into the duodenum, but it was unsuccessful, until nearly 48 hours had elapsed after admission. The tube migrated down the bowel very slowly and it was deemed wise to undertake operation in order to decompress the distended intestine.

Operation was done December 94 (10 p.m.) under cyclopropane anesthesia. The stomach was

evacuated prior to the operation with ordinary duodenal tube and this tube, as well as the Miller Abbott tube, was left in place during the operation. Procedure. Fluid distention of many segments of small intestine was found when the incision was opened. Exploration suggested the presence of a small mass in the pelvis; it could not be visualized despite placement of the patient in steep Trendelenburg position. The cecum was not distended. A low ileal loop was stripped of its content as indicated in Figure 3a and isolated between rubber covered clamps. The type of operation depicted in Figure 3 was carried out. The clamp on the distal side was removed and 500 cubic centimeters of feculent, yellowish brown fluid and 500 cubic centimeters of gas was aspirated from the loop proximal to the site of obstruction. This evacuation permitted direct visualization of the site of obstruction. A short, dense adhesive band was observed to come from the lateral wall of the pelvis and to loop over the terminal ileum, about 15 centimeters proximal to the cecum. The obstruction was 8 inches (45 cm.) beyond the site of the decompressive enterotomy opening. It was possible to pass a small curved dissector between the adhesive band and the bowel; the band was divided with scissors. The gut wall appeared to be intact; however when it was manipulated gently, it was obvious that the adhesive band had cut wide into the intestine, practically amputating the bowel. At the mesenteric border the bowel was intact; otherwise its entire circumference had been cut by the adhesive band, to such an extent that the lumen gaped widely. Only fibrin on the external wall of the bowel lent the impression that the gut wall was intact. Placement of a single row of interrupted Halsted mattress sutures of fine silk (Dehnsted D) effected a satisfactory closure. The enterotomy catheter was withdrawn, and this opening was closed in a similar manner (Fig. 3G). An aseptic enterostomy after the general plan of Witte, was placed 15 centimeters proximal to the enterotomy opening. Three grams of sulfathiazole powder was sprinkled about the site of intestinal suture. The abdominal wall was closed with interrupted sutures of fine silk and an additional gram of sulfathiazole was incorporated in the abdominal wall closure.

The operating time was 1 hour and 30 minutes. The blood pressure and pulse are recorded at 5 minute intervals throughout the procedure. A graph of the systolic blood pressure and pulse is shown in Figure 3a. Both were well sustained throughout, with surprisingly little variation.

The systolic blood pressure and pulse were recorded at relatively short intervals for many hours after operation. These are depicted in Figure 3b. No evidence of shock was observed.

Caloric and nitrogen balance was maintained during the preoperative and the early postoperative period by the daily intravenous administration of (1) 500 cubic centimeters of 10 per cent glucose solution (0.1 hours daily required for infusion) (2) 300 cubic centimeters amino acids and (3) 300 to

(The method probably will come to displace enterostomy in large number of low obstructions of the small bowel.)

400 cubic centimeters of plasma. During operation, a total of 500 cubic centimeters of plasma was given. Enough water and salt were given to maintain water and electrolyte balance. The patient's weight fluctuated less than one kilogram during the period in which hydration and nutrition were maintained by para-oral feedings.

The patient made an uneventful convalescence and was afebrile by the 6th day. The enterostomy catheter was withdrawn about the 10th day, there was no leakage. The patient remained as an ambulant patient for a week after she was allowed up. She was dismissed January 1, 1942. A recent letter, March 15, 1942, indicates that she has remained well.

Monks (1903, 1908), Moynihan (1926), Vandenberg (1920, 1941), Holden (1926), and Cheever (1932) have championed the use of operative means of intestinal evacuation. Holden employed it quite regularly. Most surgeons have been reluctant to employ such intestinal evacuation, essentially for 2 reasons: (1) the obvious hazard of spillage in the use of the Monks-Moynihan evacuation tube, and (2) manipulation incident to emptying the bowel and reefing the bowel upon the tube invited shock.

A number of experimental studies appear to support this latter contention. Laewen (1927) was one of the first to point out that shock could be produced by stripping the distended obstructed bowel. Morton (1932) confirmed the observation and, in turn, Ochsner and Storck (1936), and Sperling and Kremen (1939) have verified this observation. It is well known that trauma to the unobstructed bowel is a favorite manner employed by experimentalists to induce shock.

Whether the procedure described herein will provoke shock remains to be determined. Suffice it to say that aseptic decompressive suction enterotomy can be accomplished with minimal trauma to the bowel wall, and that no evidence of shock has been observed in the 4 patients upon whom the method has been used to date.<sup>1</sup>

#### TECHNIQUE

The technique<sup>2</sup> of accomplishing aseptic decompression suction enterotomy is depicted in

<sup>1</sup>The method has been employed now on many occasions with complete satisfaction. No evidence of shock has been observed.

<sup>2</sup>The writer is indebted to the pathological staff for permission to work out details of the use of the method on fresh cadavers. It is a debt of obligation to acknowledge the helpful co-operation of my colleagues Drs. Clarence Dennis, Arnold J. Kremen, and David State in these preliminary trials with the method.

Figure 2, and the use of the method is described in some detail in the preceding case history. It is important that the segment of bowel into which the trochar is to be introduced is emptied effectually (Fig. 1a) before the sutures are placed. A No. 22 F rectal tube is stiff enough to be advanced without difficulty into the dilated intestinal coils. The catheter exhibits multiple small perforations, not unlike the Kenyon-Pool metal abdominal suction tube. Nevertheless, it may be necessary to break the suction at intervals to obviate plugging of the holes in the tube by intestinal mucus. The writer employs the ordinary bedside 2 or 3 bottle water siphonage apparatus to secure suction. A Sprengel water pump will do. A mild source of suction appears to be most efficacious. In contradistinction to the Monks-Moynihan maneuver, practically all the manipulation concerns loops of bowel which have been emptied by suction. Monks devised intestinal evacuation to wash out toxic material from the distended bowel. The writer employs intestinal evacuation as described herein with the sole purpose of reducing distention such that the surgeon may see and deal intelligently and effectually with the obstructing agency.

As distended loops of bowel are emptied, they are reefed gently upon the catheter in the bowel, thus permitting advancement of the catheter into more proximal reaches of the distended intestinal coils. When the distention is essentially gaseous, external pressure upon the distended intestinal coils, combined with suction, suffices to effect decompression, when the distention is largely fluid in character, gentle elevation or tilting of the coils will cause the fluid contents to run in the direction of the advancing suction tube. The catheter may be withdrawn from the bowel and advanced in the other direction if desired. The Penrose drain overlying the No. 22 French suction tube<sup>3</sup> (Fig. 2) precludes contamination

<sup>3</sup>The reason the trochar is made large enough to accommodate a No. 22 F French rectal tube is that this is the smallest size in which the long rectal tube is available ready made. A trochar has been used with complete satisfaction. In an infant of 4 weeks with acute obstruction and considerable distention my colleague, Dr. Dennis improvised a small glass tube, accommodating a No. 12 French catheter prepared as shown in Figure 2E to deal with the factor of distention at operation. The plan worked admirably. Evacuation of the distended coils of gut permitted visualization and division of an adhesive band attached to the posterior abdominal wall.

of the surgeon's hands on withdrawal of the tube. The mineral oil (or better glycerine) within the Penrose drain facilitates manipulation of the suction tube within it.

#### ASEPTIC ENTEROTOMY FOR REMOVAL OF A GALL STONE

Current reports indicate that the mortality of gall-stone obstruction is still in the vicinity of 50 per cent (32). Obstruction of the intestine by a gall stone suggests a rather innocent and not potentially hazardous type of intestinal occlusion. The extraordinary peril of obstruction by a gall stone has its exploration apparently in 2 occurrences: (1) difficulty of recognition and (2) failure on the part of surgeons to remove the gall stone *aseptically*.

During the past 2 years, 3 instances of gall stone obstruction were observed in this clinic. The type of aseptic removal shown in Figure 4 was employed in these instances. There were no deaths. Segregating the intestinal loop in which the gall stone lies and stripping out its content permits the safe placement of sutures. It is never safe to place sutures in a distended intestinal bowel wall for each needle puncture will leak. After the preliminary emptying of the distended segment, however, *immediate* contraction of the circular muscle of the bowel wall occurs and the previously paper thin intestine attains more substance than the normal bowel wall. If at all possible, the gall stone should be dislodged so that the incision in the bowel wall may be made at a site where pressure has not compromised the viability of the bowel wall. If the gall stone is incarcerated it may be dealt with as indicated in Figure 4B. If the entire circumference of the bowel wall were not viable an experience which has not been encountered in this clinic, it would be wiser to resect the segment of bowel containing the gall stone. Intestinal continuity being established by an oblique end-to-end anastomosis.

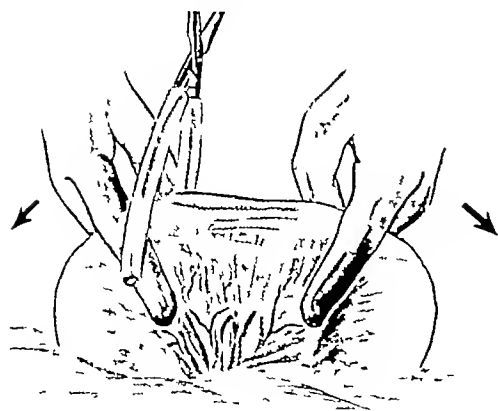
In the usual situation therefore after dislodgment of the gall stone and the segregation and stripping of the contents of the loop interrupted Halsted mattress sutures of fine silk (Deknatel D) are placed, as indicated in Figure 4A. These are pulled to either side by skin hooks, permitting the incision to be

made unhampered directly over the gall stone. As the gall stone is extruded, gentle traction is made on the sutures, and the transverse enterotomy opening may be closed without a *drop of spillage*. If no visible soiling occurs, the risk of operation is nil. In the main, a satisfactory and safe closure of the enterotomy opening may be effected with a single row of Halsted mattress sutures placed before the incision in the bowel is made. The additional placement of a few similar sutures, in a second row may be made if it is believed desirable.

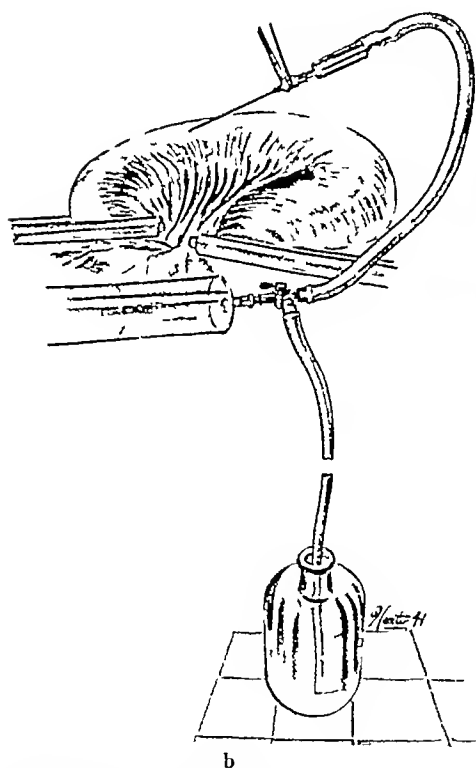
**Diagnosis.** The recognition of gall-stone obstruction has been described elsewhere (32). It may be well to point out however that obturative obstructions may be deceptive in that transient and recurring obstruction may appear to be present. The upper jejunum has a larger diameter than the ileum. In consequence, the gall stone may be arrested temporarily in its migration down the intestinal canal with periodic recurring attacks of intestinal colic, accompanied by nausea and vomiting. Only after the gall stone becomes lodged and fixed do the symptoms become definitely progressive. An obstruction which relents and recurs is very suggestive of intestinal occlusion by a gall stone. Owing to pressure necrosis at the site of incarceration of the gall stone local abdominal tenderness in well developed cases is usual.

#### Case histories of patients with gall stone obstruction of small intestine

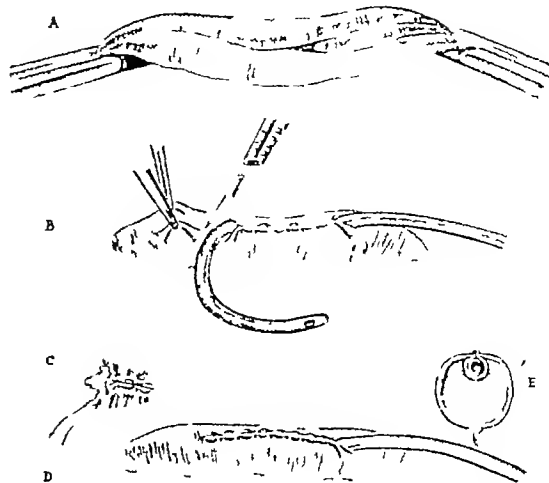
Mrs. A. T., aged 70 years. Only Noop 56 8442 was admitted because of back pain 48 hours before operation. Abdomen then negative. Thirty-six hour story of pain and vomiting. Abdomen tender. Intestinal colic present. X-ray film showed distended intestinal coils and a gall stone is visualized. Attempt was made to crush the gall stone over gauge with large Pa crushing clamp. The clamp as sprung but the stone as not dented. Operation is depicted in Figure 4. February 3, 1940, after temporary suction, removal of large gall stone was accomplished. Gall bladder region was not examined. After completion of operation, it was noted that gall stone was faceted. Convalescence as uneventful. Patient returned to hospital on April 4, 1940, with story of recurrent pain of 3 days duration. Study showed moderate intestinal distention. Miller Abbott 4 decreased distention somewhat. Because of facet on large gall stone removed from bowel months ago, it was believed that patient had another gall stone in the bowel. At operation, a dense



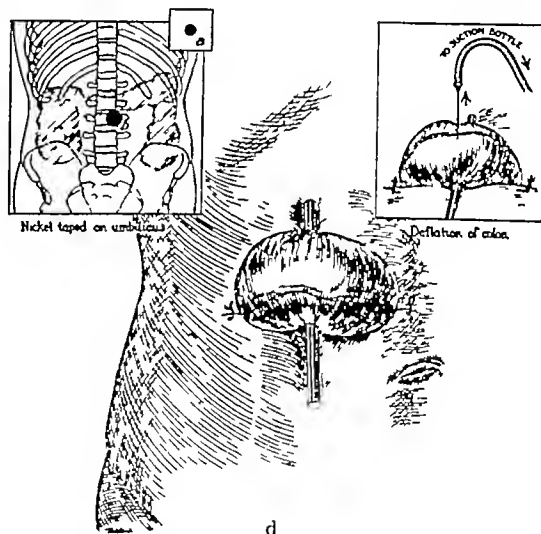
a



b



c



d

aseptically without spillage a, Method of stripping a distended segment of small intestine, which may be delivered onto the abdominal wall, prior to performance of enterostomy (see c) b, Alternative method of decompressing a distended segment of small intestine when it can not be delivered c, The writer's adaptation of the Witzel technique of enterostomy for obstruction d, Method of tapping the obstructed colon aseptically

Fig 1 Techniques employed in this clinic to secure surgical decompression of distended bowel in the presence of obstruction All of these procedures may be performed

adhesive bands were found engaging a loop of bowel. The larger band had cut a deep groove into the bowel wall. The bands were cut, and interrupted Halsted mattress sutures were employed to infold the groove in the bowel wall. Palpation of the gall bladder dis-

closed that stones were absent. The patient remained well.

Mrs E V, aged 62 years, Univ Hosp No 657357, a small obese woman weighing 200 pounds, was admitted to the hospital October 7, 1940, be-

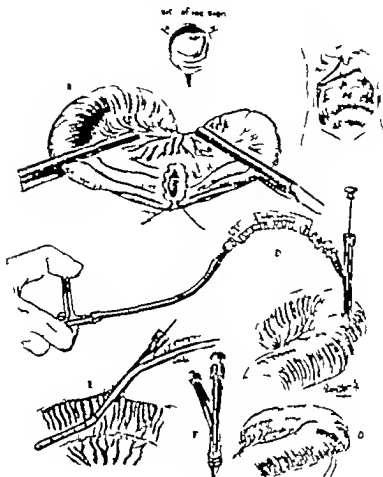


Fig.

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cause of story of abdominal pain of 3 days duration. Feculent vomiting. X-ray films revealed considerable intestinal distention and gas as visualized in biliary ducts. (After the gall stone as found in the bowel, the gall stone could be identified on the x-ray film). Blood sugar was 355 milligrams per cent. Sugar as present in the urine. After fluids, suction and insulin the patient was operated upon as shown in Figure 4. The gall stone could not be dislodged. A large non-viable flap of bowel overlies the stone. It could have been smarterly excised this flap as shown in Figure 4B. After removal of the stone when the sutures were pulled up, the flap almost occluded the lumen. A proximal enterostomy was made. The gall stone removed as indicated but the patient's condition was too poor to permit examination of the gall bladder. Convalescence satisfactory. Because the gall stone removed as

indicated and because of the compromise of the lumen by the large erosion of the site of enterostomy, the patient was dismissed from hospital with the enterostomy in place. Patient returned to outpatient clinic on December 3, 1940, and as instructed to clamp the enterostomy tube. The drainage from it had been slight. When she returned again on December 9, 1940, the tube as withdrawn, she returned the next day, and there had been no drainage from the site of enterostomy. The patient has remained well.

Mrs. F. C. aged 58 years, Univ. Hosp. No. 70079, admitted to the hospital October 9, 1940, with a history of pain and vomiting. Moderate intestinal distention as observed on x-ray film also gas in the biliary system. Operation (Dr. C. Dennis). A large gall stone as found in the terminal ileum and removed as indicated in Figure 4. On December 4,

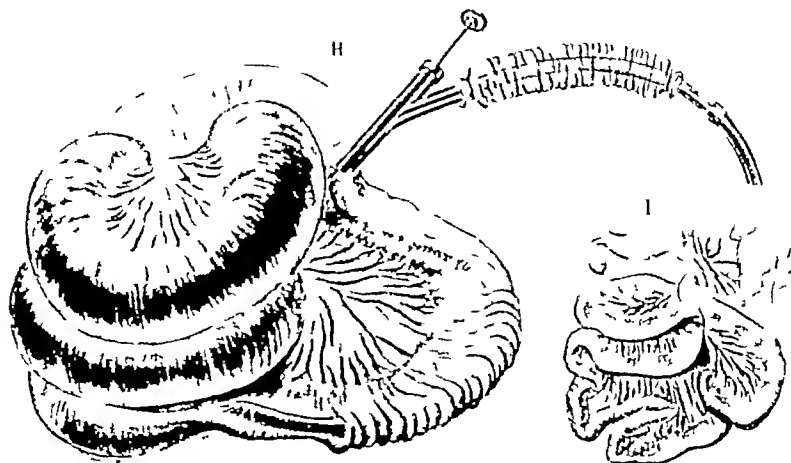


Fig 2 Technique of aseptic decompressive suction enterotomy A, Distended in testinaleous B, An intestinal loop near the conjectured site of obstruction is delivered and segregated between rubber-covered intestinal clamps, after being stripped, as indicated in Figure 1a A pursestring suture is placed and an incision, transverse to its axis, is made in the bowel wall down to the mucosa C, The length of the incision D, The trochar is thrust into the bowel and the pursestring is tied A T tube, with the sidearm held vertically, permits the operator to make and break the suction if the intestinal mucosa exhibits a tendency to cling to the perforations in the tube The trochar accommodates a No 22 F long rectal tube The Penrose drain, with glycerine within it, facilitates manipulation of the rectal tube and prevents soiling or spillage E The trochar in operation, in a sectional view The small perforations in the catheter preclude injury to the bowel during suction F, The intestinal trochar G, Closure of the enterotomy opening with interrupted Halsted mattress sutures of fine silk, after the obstructive agency has been dealt with H, How intestinal evacuation is effected by mild suction applied to the intestinal trochar I The volumetric reduction effected by intestinal evacuation affords an opportunity of determining the nature of the obstructing mechanism

1940, the patient returned for removal of the gall bladder and repair of the cholecystoduodenal fistula (Dr Dennis) The patient has remained well

#### OPERATION FOR NONROTATION

In nonrotation of the midgut loop the small intestine lies on the right side of the abdomen and the colon on the left These patients, frequently, are subject to periodic attacks of volvulus of the small intestine occasioned by the incomplete fixation of the mesentery of the small intestine The writer has had occasion to operate upon a few such patients for recurrent pain and obstruction Three operations similar to that depicted in Figure 5 have been performed, the first having been done June 23, 1938 The primary consideration is to attempt to secure mesenteric fixation for the small intestine in such a manner that it is less likely to undergo torsion It occurred to the writer that the best manner in which to accomplish this end was to begin by returning the small

intestine to its normal habitat By making the two incisions shown in Figure 5 b, the colon and small intestine can be mobilized quite easily, thus permitting replacement of the colon in its normal position A hole is made, then, in the transverse mesocolon and the small intestine is dropped through this aperture As this maneuver returns the small intestine to its normal position, it is observed that if the last ileal loop is pushed through the new aperture in the transverse mesocolon, a twist is left in the ascending colon I propose, therefore, to deal with this situation as shown in Figures 5 and 6 The terminal ileum is divided about 15 centimeters proximal to the cecum, the distal end is closed, a catheter being threaded into it and through the ileocecal valve into the cecum This short loop of ileum is then anchored to the lateral abdominal wall, and the catheter is brought out as a safety vent, through a stab wound The prox-

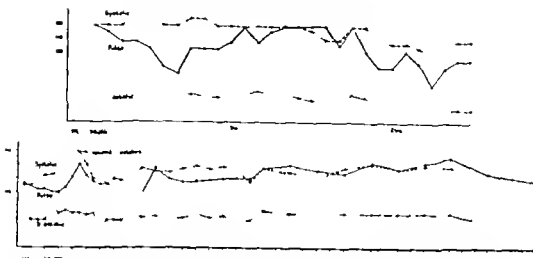


Fig. 3. Chart of blood pressure and pulse in the patient Mrs. L. B. (Case 3) upon lumbosacral decompressive section enterotomy as performed. a, above, Pressure and pulse recorded at five minute intervals during the operation. b, fall in pressure—usual pulse fluctuations in an ill patient.

b, Pressure and pulse recordings at frequent intervals for 30 hours after operation. Use of exaggerated Trendelenburg position after operation caused an elevation of pressure. Lowering of the bed—patches on the chest frame reduced the pressure to the earlier level.

small position of the divided ileum is anastomosed obliquely end-to-side to the cecum. It might appear that after division of the terminal ileum an oblique end-to-end anastomosis could be effected; however in order to mobilize the terminal ileum adequately to permit this procedure it would become necessary to divide some of the mesentery of the terminal ileum, compromising its blood supply. Hence, the operation as depicted in Figure 3 is the procedure of choice.

It now remains to secure satisfactory anchorage of the colon to restore the normal relations of cecum, ascending colon, hepatic flexure and proximal position of the transverse colon. This is not difficult to do (Fig. 5 c) and is accomplished readily by the placement of a few interrupted silk sutures. The more difficult task, now remaining, concerns securing mesenteric fixation for the small intestine. This is not accomplished so readily for the small intestine is pedicled frequently on a narrow stalk of mesentery. Yet, now with the normal horse-shoe-like boundaries of the colon re-established the whole mid-abdomen is available for occupancy by the small intestine. A few well placed sutures between the mesentery of the small intestine and the posterior parietal peritoneum will serve to anchor the

small intestine in a more satisfactory manner.

The writer has found no mention in the literature of a similar operation for nonrotation. In response to an inquiry (August 7, 1941) a number of American Surgical colleagues (36), who have been interested in anomalies of intestinal rotation, wrote me that they were unfamiliar with the operation described herein. Obviously this is not an operation to be performed during an obstructive episode. It would appear however that the operative procedure has some worth to recommend it for the patient with nonrotation who suffers periodic bouts of obstruction. It has the special merit of restoring the configuration of the final counterpart of the fetal mid-gut loop to the position occupied normally by these mature intestinal segments.

Case histories of patients having operation for nonrotation. Three patients, 2 boys (10 and 14) and a man of 26 were operated upon because of periodic attacks of abdominal pain and vomiting. All three presented evidence of nonrotation of the intestine. Cases 1 and 3 exhibited complete nonrotation of the mid-gut loop (Dotts' (7) Group I, in derangements of the second state of intestinal rotation). Case 2 presented partial nonrotation (Dotts' Group III malrotation). Cases 1 and 3 presented, in

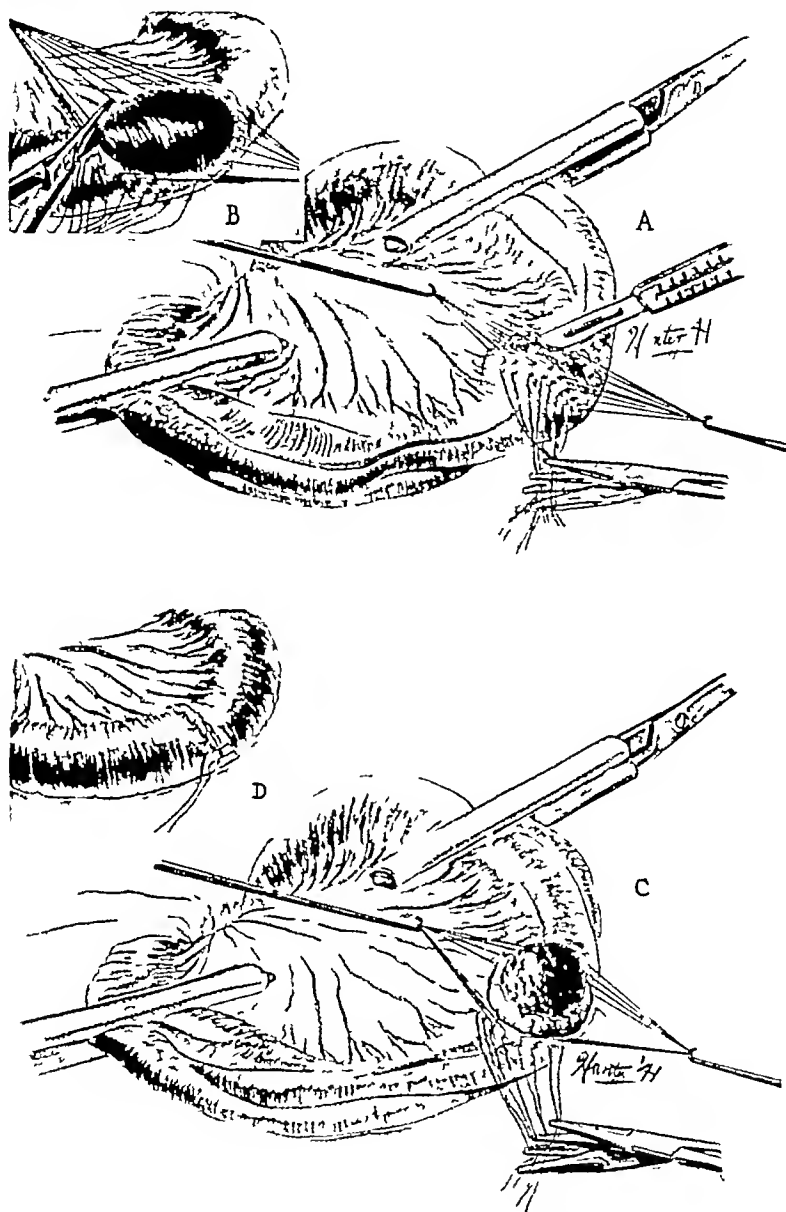


Fig 4 Technique of aseptic enterotomy for removal of a gallstone A, After evacuation of content of loop as shown in Figure 1a, interrupted Halsted mattress sutures of fine silk are placed A transverse incision is made between the sutures, which are pulled aside with skin hooks B, A scheme of excising devitalized bowel wall over the incarcerated stone, in order to obviate narrowing of lumen from overinversion of tissue C, Extrusion of the stone Preliminary evacuation of the content of the segment prior to segregation between clamps precludes spillage D, Closure of enterotomy opening is effected by pulling up the sutures An additional row may be placed, if desired



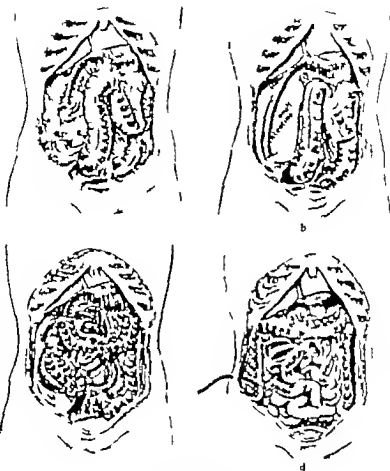


Fig. 5  
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addition extrinsic duodenal stenosis (Waugh-Ladd compression syndrome). The type of corrective repair of the nonrotation shown in Figure 5 was undertaken.

CASE H. B. aged 14 years, U Hosp. N

On August 1942 fourth patient, M. D. W. aged 3 years, U. Hosp. N. 669774, was operated upon for complete nonrotation. Dist. group. The operation described herein was done—however, an exploratory on the terminal ileum was not done as directed in view of incision after transsection of the lower ileum and division of its mesentery the terminal ileum did not appear viable. It is excised and anastomosis was done also. The patient had suffered periodic attacks of bowel obstruction since birth. The patient has remained well since operation.

A striking finding in this case as in others, mentioned herein, was the peculiar distribution of the mesenteric vessels, particularly those to the right half of the colon. An attempt was made to ascertain whether any obstructive mechanism was present to account for the finding. The superior mesenteric vessel was traced up to the inferior border of the pancreas. In portal vein was uncovered in the postduodenal position. Upper duodenum beneath the pancreas, along the course of the portal vein, was opened out. All of these maneuvers failed to disclose any obstructive mechanism. Unfortunately, the mesenteric vessels posterior was not dissected. The liver appeared normal.

669774 This boy was admitted June 1935, because of periodic vomiting. In addition, there had been periodic attacks of abdominal pain. A few years ago, the appendix removed in one of these attacks. The patient has just recovered from a severe attack of abdominal pain and vomiting of days duration. X-ray studies demonstrated an enormous dilatation of the duodenum, it being full as large as the antrum of the stomach. There was also about 80 per cent retention of barium in the stomach after 4 hours. After 4 hours, there was still good deal of barium left in the stomach. The small intestine was largely on the right side of the abdomen and the colon on the left.

Operation as performed June 3, 1935 under cyclopropane anesthesia (operating time 3 hours). Numerous adhesions are encountered when the peritoneal cavity is opened, suggestive of an antecedent peritonitis. The greater omentum is 1

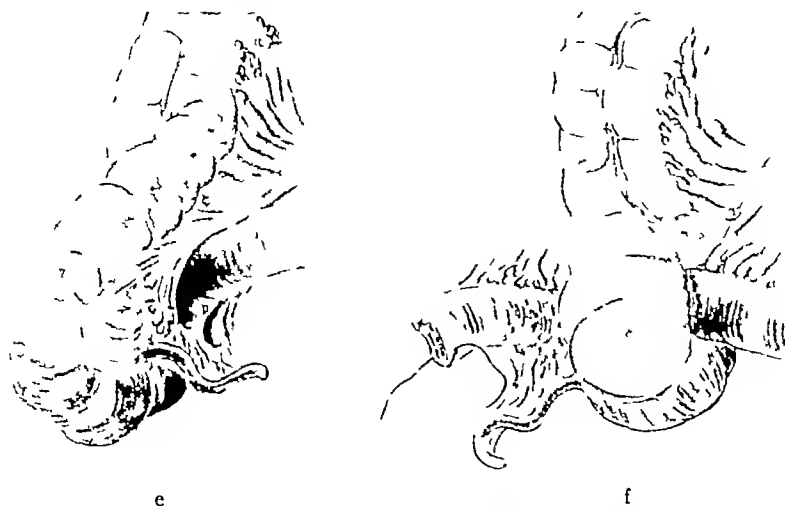


Fig 5 Operation for nonrotation. a, Condition as noted at operation. b, Peritoneal incisions to mobilize the bowel. c, The colon has been pulled to the right, a rent is made in the transverse mesocolon, and the small intestine is dropped through it into its normal inframesocolic position. d, Severance of terminal ileum to effect the complete return of the small intestine below transverse mesocolon. An oblique end-to-side, closed anastomosis is made between the ileum and cecum. A catheter is threaded through the terminal closed segment of ileum into the cecum to be employed as a decompressive vent during the recovery period. e, Effect of attempting complete return of the small intestine through the slit in the transverse mesocolon—a twist remains in the ascending colon. f, Transection of the ileum affords a better solution. The proximal ileum is anastomosed obliquely, end-to-side to the cecum or ascending colon, and the distal segment is inverted—a No. 14 urethral catheter being threaded into it to afford a safety vent.

tached between stomach and duodenum and had no colonic attachment on the right side of the abdomen. The enormously dilated duodenum lay anterior to the superior mesenteric vessels. There were a number of dense, fibrous, cord-like bands crossing the duodenum near the spine (Waugh-Ladd compression syndrome). The entire small intestine, cecum, ascending colon and hepatic flexure had a common mesentery. The small intestine occupied the right portion of the abdomen, and the colon was entirely on the left side.

The operative procedure consisted of division of the adhesive bands compressing the duodenum and freeing up of the entire duodenal loop. The attachment of omentum between stomach and duodenum was undone, and eventually the omentum was reattached to the right transverse colon which had been entirely devoid of an omental attachment, in turn, the omentum was sutured to the stomach, thus establishing the normal relationship. The liberated right colon, including cecum, ascending, and the proximal half of the transverse colon, was pulled to the right and fixed in the normal position for these components. It was possible, in this way, to reconstruct the normal configuration of arrangement of intestinal segments, the only exception being that the first jejunal loop emerged from the right of the spinal column instead of from the left, as is usual in

the presence of a fully developed ligament of Treitz. The duodenum now lay behind the transverse mesocolon, whereas at the beginning of the operation the duodenum was in front of it.

The patient convalesced uneventfully and was dismissed on July 6, 1938, 13 days after operation. A roentgen study, November 19, 1938, demonstrated a normal configuration of arrangement of the intestinal segments, including stomach, duodenum, small intestine, and colon. The patient has grown in height and size, exhibiting a weight gain of more than 50 pounds. He has been completely free of abdominal pain.

Mr J. L. v. E., aged 26 years, Univ. Hosp. No. 644839, was admitted on the Medical Service October 3, 1938, and transferred to the Surgical Service October 20, 1938, with complaint of periodic attacks of vomiting and bowel obstruction all his life. As an infant and a child, the patient had so many attacks of abdominal pain and vomiting that his mother had little hope of being able to raise him. X-ray study disclosed nonrotation of the small intestine, it occupying the right side of the abdomen and the colon the left side.

Operation was done October 24, 1938 (cyclopropane anesthesia, operating time 2 hours, 15 minutes). The duodenum was intraperitoneal, however, the third portion inclines somewhat to the left, and

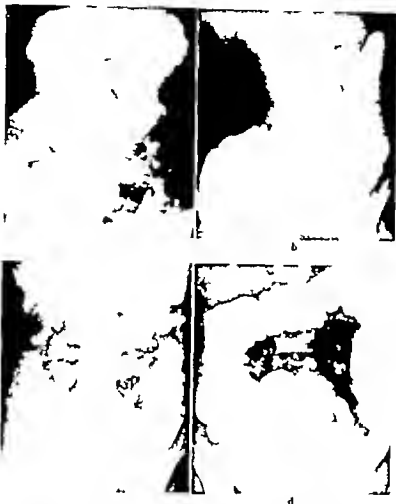


Fig. 6. Roentgenograms of perrotation of the intestine before and b, and after, and d, operation (Case 4). a, The small intestine lies on the right side of the abdomen. b, The colon lies on the left. After operation (Fig. 5) the small intestine lies still. c, The U loop of the colon. d, Position of the colon and terminal ileum outlined by barium enema.

there was some fixation of the duodenum on the posterior abdominal wall, before it merged with the jejunum. The duodenum did not lie behind the superior mesenteric vessels. The mesenteric arteries appeared to come off the parent vessel in fan-like fashion as far as the transverse colon. The transverse mesocolon was fully developed. The fixation of the left colon was normal, save that the splenic flexure did not go as high as is usual.

**Operative procedure.** The incisions shown in Figure 5 b were made and the jejunal coils and right colon freed up. When the colon was drawn to the right the coils of small intestine were confined above and to the right of the mesocolon. It became apparent that, in order to re-establish the normal situation, hole would have to be made in the transverse mesocolon, through which the intestinal coils could be returned to their normal position, beneath the transverse mesocolon. Such hole was made the mesentery

being incised below the marginal vessels of the transverse colon at the root of the mesentery. After repeated trials, it was observed that all the coils of small intestine could be returned through this aperture, but a twist remained in the ascending colon. It was decided to absorb this 360 degree twist over the entire extent of the ascending colon (see Case 3). The colon was fixed in the normal position. The duodenum was returned to normal position, but it could not be brought behind superior mesenteric artery.

The patient seemed to have considerable pain after operation, though the operative reaction was not unusual. The torsion, which was allowed to remain in the ascending colon, as source of worry and days later the abdomen was re-explored. There was no suggestion of compromise of the blood supply of the right colon, but an appendicectomy was made to obviate great increases of intraluminal tension in the cecum. The patient convalesced satisfactorily.

# WANGENSTEEN NEW OPERATION IN BOWEL OBSTRUCTION

and was transferred back to the medical service November 8, 1938

The patient has done well, save for occasional slight twinges of abdominal pain. There have been no attacks like those prior to operation, the patient has been able to work and he eats everything. On semiannual visits to the out patient clinic, the patient reported himself as doing well. Recently he was inducted into the army for active military duty.

CASE 3 J A, aged 10 years, Univ Hosp No 685424, was admitted to pediatric service September 18, 1939, complaining of frequent recurrent spells of periodic vomiting, dizziness, and malnutrition. The vomiting was of such a character as to arouse suspicion of the presence of an intracranial compressive lesion. X-ray studies revealed a considerably dilated duodenum, suggestive of extrinsic duodenal stenosis.

Operation was done September 25, 1939, under cyclopropane anesthesia (operating time 3 hours, 15 minutes). The duodenum was very much dilated. The superior mesenteric artery ran behind the duodenum and the coils of small intestine obscured the right colon. The cecum lay to the right of the vertebral column, it had not completely descended and the ileum entered it from the right (Dotts' Group III, malrotation of midgut loop). Dense adhesions compressed and obstructed duodenum at usual site of fixation near spine. The right half of greater omentum ran between stomach and duodenum, no omental attachment to transverse colon in its right half.

The dense adhesive bands, narrowing and compressing the duodenum were cut, the right colon was freed up and brought to its normal position. The veins in the mesentery were unusually large. The transverse mesocolon was fully developed, and it was necessary to make an incision in it, in order to return the coils of small intestine to their normal location. When the terminal ileum was pushed through the aperture in the transverse mesocolon, a 360 degree of torsion remained in the ascending colon. The terminal ileum was divided approximately 15 centimeters proximal to the cecum. This maneuver permitted delivery of the entire proximal ileum through the rent in the transverse mesocolon. It was our intention to tip the short distal segment of the ileum to lie below and within the confines of the colon, nevertheless, there is a tendency for the coils of small intestine not to occupy the upper left quadrant of the abdomen. The functional results of the operation, though not brilliant, have been very satisfactory.

It is emphasized, further, that extrinsic duodenal stenosis and nonrotation may coexist. Recently during the course of a gastric resection for an obstructing bleeding duodenal ulcer, nonrotation of the bowel was discovered in another patient. Mr. W. E., aged 23 years, Univ Hosp No 72-097. The cecum and ascending colon were remarkably free (cecum mobile). Should this patient subsequently require operation for the nonrotation I would propose doing a hemicolectomy. Instead of the operation herein described in that the mobile cecum and ascending colon would be dealt with effectively. Because of the unusual mesenteric attachment an ante nor rather than a retrocolic anastomosis had to be done at gastric resection.

intestinal motility to be normal. The pelvic colon was unusually redundant. The boy's mother wrote, April 1, 1942, in response to an inquiry "John was getting along nicely and there was no return of the stomach trouble. Three months ago, while out hunting rabbits with his brother, John was shot and killed accidentally."

It is to be noted that, in Case 1 the entire midgut loop had a common mesentery. That is the arterial segment (proximal to the embryonic vitelline intestinal duct) and the postarterial (portion of the bowel between vitelline duct and midtransverse colon) were pedicled on a common jejunoileal colonic mesentery. The right colon did not have its own mesentery and the transverse mesocolon was not developed. In consequence, it was possible to restore the final normal configuration of arrangement of intestinal segments, merely by freeing and pulling the colon to the right and fixing it in its usual position. In Cases 2 and 3, however, in which the transverse mesocolon was fully developed, it became necessary to establish an aperture in it, through which the coils of small intestine were dropped, in order to place them in their normal position below the transverse mesocolon. This maneuver necessitates division of the terminal ileum and an oblique, aseptic end-to-side anastomosis between the ileum and the cecum. It is recommended, further, that the short terminal segment of ileum be employed as a temporary decompressive vent, to obviate distention of the cecum during convalescence. This operative procedure succeeds in restoring in a fairly normal manner, the usual normal arrangement of the intestinal segments. In the main, though the small intestine comes to lie below and within the confines of the colon, nevertheless, there is a tendency for the coils of small intestine not to occupy the upper left quadrant of the abdomen. The functional results of the operation, though not brilliant, have been very satisfactory.

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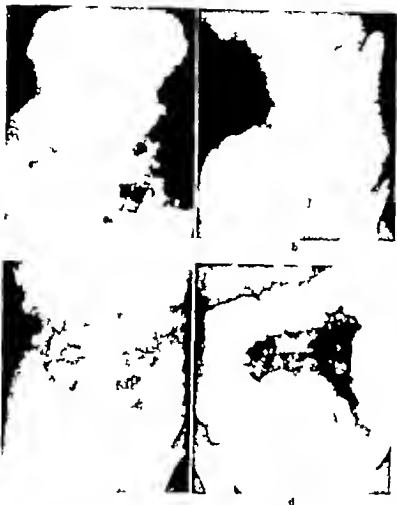


Fig. 4. Roentgenograms of nonrotation of the intestine before and b, and after, and d, operation (Case 3). a, The small intestine lies on the right side of the abdomen. b, The colon lies on the left. c, After operation (Fig. 3) the small intestine lies within the U-loop of the colon. d, Position of the colon and terminal ileum outlined by barium enema.

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During the early convalescence, there was considerable intestinal distention (It would have been marter, undoubtedly, to employ the terminal ileum or prophylactic decompression of the cecum as is shown in Figure 5 d). The patient was dismissed from the hospital October 28, 1939. He returned to the out patient clinic 6 months later, exhibiting a 10 pound weight gain. A stasis ray showed the gastro-

intestinal motility to be normal. The pelvic colon was unusually redundant. The boy's mother wrote, April 1, 1942, in response to an inquiry "John was getting along nicely and there was no return of the stomach trouble. Three months ago, while out hunting rabbits with his brother, John was shot and killed accidentally."

It is to be noted that, in Case 1 the entire midgut loop had a common mesentery. That is the arterial segment (proximal to the embryonic vitelline intestinal duct) and the postarterial (portion of the bowel between vitelline duct and midtransverse colon) were pedicled on a common jejunoileal colonic mesentery. The right colon did not have its own mesentery and the transverse mesocolon was not developed. In consequence, it was possible to restore the final normal configuration of arrangement of intestinal segments, merely by freeing and pulling the colon to the right and fixing it in its usual position. In Cases 2 and 3, however, in which the transverse mesocolon was fully developed, it became necessary to establish an aperture in it, through which the coils of small intestine were dropped, in order to place them in their normal position below the transverse mesocolon. This maneuver necessitates division of the terminal ileum and an oblique, aseptic end-to-side anastomosis between the ileum and the cecum. It is recommended, further, that the short terminal segment of ileum be employed as a temporary decompressive vent, to obviate distention of the cecum during convalescence. This operative procedure succeeds in restoring in a fairly normal manner, the usual normal arrangement of the intestinal segments.<sup>1</sup> In the main, though the small intestine comes to lie below and within the confines of the colon, nevertheless, there is a tendency for the coils of small intestine not to occupy the upper left quadrant of the abdomen. The functional results of the operation, though not brilliant, have been very satisfactory. It is emphasized, further, that extrinsic duodenal stenosis and nonrotation may coexist.

<sup>1</sup>Recently during the course of a gastric resection for an obstructing bleeding duodenal ulcer, nonrotation of the bowel was discovered in another patient, Mr. W. E., aged 23 years, Univ. Hosp. No. 722007. The cecum and ascending colon were remarkably free (cecum mobile). The cecum and ascending colon were remarkably free (cecum mobile). Should this patient subsequently require operation for the nonrotation I would propose doing a hemicolectomy instead of the operation herein described in that the mobile cecum and ascending colon would be dealt with effectively. Because of the unusual mesenteric attachment an ante- nor rather than a retrocolic anastomosis had to be done at gastric resection.

## SUMMARY AND CONCLUSIONS

A general improvement has come about in the results of treatment of acute intestinal obstruction. From surgical clinics professing an especial interest in the problem a persistent mortality varying from 12 to 30 per cent is reported still. Strangulating obstructions and late cases of simple obstruction with great distentions contribute largely to this residual mortality. There is however a definite mortality of treatment which should be identified. Too enthusiastic reliance upon suction management contributes to the mortality of treatment.

Reduction in the existent residual mortality of acute intestinal obstruction must come about largely through improvement of surgical techniques. When surgeons learn that aseptic surgical decompressions are mandatory for success with operative maneuvers, in the presence of obstruction and large distentions, general betterment will become apparent again in the management of bowel obstruction. Now a surgical tap of a distended obstructed intestine is done as equally as important as the choice of procedure. The experience of this clinic with nonviable strangulated bowel suggests that primary intestinal resection with oblique end-to-end anastomosis, the closed technique being used, is a safe and satisfactory procedure. During the past year in nine consecutive patients with nonviable strangulated bowel there were no deaths.

Three new operative techniques for employment in the bowel obstruction problem are described: (1) Aseptic decompressive suction enterotomy. This procedure affords a means of relieving intestinal distention at operation in an aseptic manner permitting visualization of the site of obstruction thus enabling the surgeon to deal more effectually and directly with the obstructing agency. (2) Method for aseptic removal of an obstructing gallstone. (3) A corrective operation for nonrotation of the intestine. Case histories illustrating each operative procedure are cited.

It is concluded that for the immediate years which lie ahead better results in the treatment of acute intestinal obstruction will be achieved, essentially by improvement in surgical techniques. When surgeons master the problem of decompressing a distended bowel at operation,

the present mortality of obstruction though considerably better than that of the prewar era, will appear large in contrast with that to be achieved by a well balanced use of conservative decompression, and timely and precisely executed aseptic surgical procedures.

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# ABSORPTION OF SULFONAMIDES DURING LABOR

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**I**NTRAPARTUM infections frequently present problems of management which are among the most difficult that the obstetrician is called upon to meet. When the infecting organism is of a relatively avirulent strain, the infection benign in nature, and when spontaneous delivery is imminent or delivery by forceps can be easily effected, there may be little cause for anxiety. In such cases prompt clinical cure may usually be anticipated following the emptying of the uterus. Yet all too often are fulminating infections encountered at a time when vaginal delivery cannot safely be performed. In these cases uterine inertia is a common finding, and the uteri of such patients are notoriously unresponsive to pituitrin stimulation. Cesarean section by one of the several extraperitoneal techniques may be resorted to, but most cases of this nature are more safely treated by the radical operation, which entails the loss of the uterus and the cessation of reproductive activity. Moreover, many infants which are delivered after hours of exposure to infected environs, including circulating bacterial toxins, and the aspiration of infected amniotic fluid, are already dead or are so embarrassed at birth that they cannot survive. Many succumb in the early neonatal period to pneumonia, septicemia, or meningitis.

The sulfonamide group of drugs have been of unquestioned value in the treatment of many types of intercurrent infections during pregnancy and have served also as a valuable adjunct in the treatment of puerperal infection. They have likewise offered new hope in the management of severely infected patients during labor. The majority of the fulminating and heretofore fatal cases of intrapartum infection are caused by the beta hemolytic streptococcus or staphylococcus. Another relatively common offender is the Welch

bacillus. Fortunately infections due to these organisms are dramatically responsive to appropriate sulfonamide therapy.

The efficacy of the sulfonamides when administered by mouth depends upon the establishment of an adequate concentration of the drug in the bloodstream. Numerous clinical studies have demonstrated that such a blood level may be anticipated within 4 hours after the oral administration of the initial large dose, usually 4 grams of sulfanilamide, sulfapyridine, sulfathiazole, or sulfadiazine, in the treatment of adults. It has been tacitly assumed that similar conditions prevail during labor and that programs of therapy which have been worked out for nonpregnant individuals are similarly applicable to parturient women.

It is the purpose of the present report to show that such assumptions are unwarranted. The currently popular sulfonamides are, in a great proportion of the cases, poorly absorbed following their oral administration during labor. A large initial dose fails to result in an effective concentration of the drug in the bloodstream. Thus for prompt therapeutic action parenteral administration must be resorted to.

## OBSERVATIONS

In the course of a study of the placental transmission of sulfanilamide (15), 0.06 gram of this drug per kilogram of body weight was given orally to 16 women in labor. Samples of maternal blood were obtained at the time of delivery, which ranged from 1 to 38 hours after administration of the drug. In the majority of cases analysis revealed blood concentrations of sulfanilamide of the same order of magnitude as is normally observed during treatment of nonpregnant individuals with similar doses. Results in 12 of the 16 cases formed a rather smooth curve, when the blood levels were plotted against the time after administration, a peak of 6.4 milligrams per cent



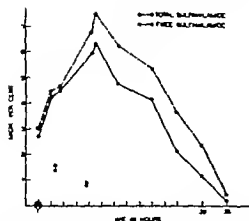


Fig. 1. Absorption of sulfanilamide during labor. Each patient received single dose of .06 gram per kilogram. Blood levels of representative patients with normal values are shown by solid and broken lines, abnormally low values by unconnected dots and circles.

of free sulfanilamide (7.6 milligrams per cent total) occurring at 5½ hours (Fig. 1). Four patients, however, possessed blood sulfanilamide levels at delivery which were strikingly lower than was anticipated. In 1 of these cases an additional blood determination about 1½ hours before delivery confirmed the existence of an extremely low sulfanilamide concentration. In another case no sulfanilamide was detectable in the blood 1 hour after administration (Fig. 1). All analyses were done in duplicate in the laboratory of Dr. E. K. Marshall Jr. by the methods and modifications devised by him and his associates.

No apparent explanation for these anomalous blood levels was at hand. Occasionally

vomiting occurred soon after the drug was given, but none of these cases were included in the study. Suspecting that factors related to the process of labor might be involved, we gave the same 4 patients another single dose of sulfanilamide by mouth about a week after parturition. Dosage of the drug was calculated as before, allowance being made arbitrarily for a 7 kilogram weight loss. Blood sulfanilamide determinations were made at intervals of 1, 3, 5 and 7 hours. In each instance the resulting curve showed excellent absorption of the drug, with a maximal concentration of about 8 milligrams per cent of free sulfanilamide appearing between 1 and 5 hours after administration. Absorption curves for 2 patients are shown in Figures 2 and 3, to illustrate the striking contrast between the blood sulfanilamide levels attained during labor and those resulting from similar doses during the puerperium.

With the advent of sulfathiazole and its rapid popularization it became of interest to compare the behavior of this drug during labor with that of sulfanilamide. Accordingly a single dose of 5 grams of sulfathiazole was given orally to a series of 8 patients during labor and samples of venous blood were obtained at delivery which caused at various intervals between 1 and 11 hours later. The results of the blood determinations were little short of amazing (Table I). Despite the general experience that sulfathiazole is more rapidly absorbed than sulfanilamide under ordinary circumstances the blood concentrations of the former which were attained during

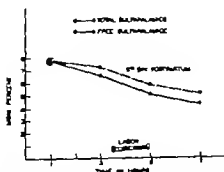
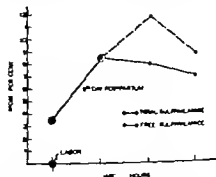


Fig. 2 and 3. Blood sulfanilamide levels of patients with abnormally poor absorption during labor compared



with blood concentrations following injection of similar dose (adjusted for weight loss) in puerperium.

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TABLE I—BLOOD SULFATHIAZOLE LEVELS AT VARIOUS INTERVALS AFTER ADMINISTRATION OF SINGLE 5 GRAM DOSE BY MOUTH DURING LABOR

Patient	Interval hours:minutes	Blood sulfathiazole mgm per cent	
		Free	Total
I G	1 00	o	o
B J	1 20	o	o
S R	1 40	o	o
P W	3 40	Trace	Trace
A J	4 30	Trace	
C S	5 45	1 1	
D E	6 00	2 1	
M R	11 00	Trace	

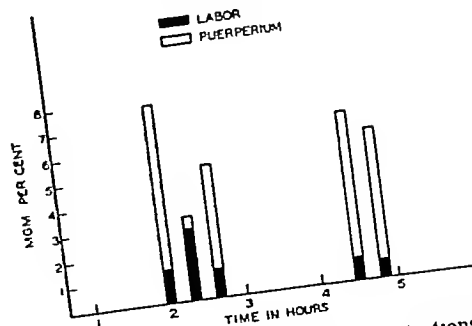


Fig 4 Blood sulfadiazine (free) concentrations of 5 patients at various intervals after ingestion of single 5 gram dose during labor, contrasted with blood levels in same patients after same intervals following ingestion of 4-5 gram dose in puerperium

labor were uniformly lower than in the sulfamidamide series. Indeed in 6 of the 8 cases no more than a trace of sulfathiazole, too little to allow accurate quantitative determination, could be detected. In several of these cases analysis was repeated after acid hydrolysis, but the amount of the acetylated form of the drug was uniformly too little to alter the results significantly. Analysis of fetal blood obtained from the umbilical cord, and of amniotic fluid, likewise showed little or no sulfathiazole, in accordance with the maternal blood levels.

In only 2 specimens, which were obtained at 5¾ hours and 6 hours respectively after administration of the sulfathiazole, could measurable amounts of the drug be detected in the maternal blood. Even these bloods, however, contained only 1 1 and 2 1 milligrams per cent, values well below the anticipated levels.

Observations were then extended to include the currently popular sulfadiazine. A single dose of 5 grams was given by mouth to a group of 5 laboring women at intervals ranging between 2 hours and 4 hours 50 minutes before delivery. Sulfadiazine determinations were made on venous blood obtained at the time of birth. Here again, in contrast to the usually uniform and rapid absorption of this drug, the blood levels attained during labor were surprisingly low, none exceeding 2 8 milligrams per cent (Fig 4). Even smaller concentrations existed in the cord blood and amniotic fluid.

As a control to this series of observations, the same 5 patients, on the 3d or 4th day of the puerperium, were given another dose of

sulfadiazine orally, this time, however, only 4 5 grams, allowance being made arbitrarily for a 10 per cent decrease in body weight. Blood specimens were obtained from each patient after exactly the same interval as had elapsed during labor. As was expected, the sulfadiazine promptly appeared in the bloodstream. At corresponding times the puerperal blood levels exceeded several fold, in most instances, the concentrations attained during labor (Fig 4).

## ANALYSIS OF STUDY

Marked contrast is afforded by the uncertainty of absorption of sulfamidamide, sulfathiazole, and sulfadiazine when given in a single large oral dose during labor and the blood concentrations of these drugs which are rapidly attained under ordinary circumstances. Most striking was the anomalous failure of absorption of sulfathiazole. In non-pregnant individuals a single dose of 5 grams of this drug was followed in 2 to 6 hours by blood levels as high as 7 2 to 9 5 milligrams per cent (17). In 8 women receiving the same dose of sulfathiazole during labor, on the other hand, a maximal concentration of 2 1 milligrams per cent was obtained, and the blood of 6 patients failed even to show measurable quantities of the drug after periods ranging up to 11 hours. Even when smaller single doses of sulfathiazole were administered to nonpregnant individuals, much higher blood levels have been consistently attained (1, 6,

11 12 14) After a single dose of only 3 grams the blood concentrations remained above 4 milligrams per cent for 4 to 6 hours (12)

Similarly in the case of sulfadiazine a single oral dose of 5 grams given to nonpregnant patients resulted in a maximal blood concentration of 7.7 to 10.8 milligrams per cent 4 to 6 hours later (10). Of our 5 patients who received the same dose during labor the average blood level between 2 hours and 4 hours 50 minutes later was, by contrast only 1.3 milligrams per cent. Smaller doses of this drug likewise resulted in consistently greater blood concentrations after similar intervals in nonpregnant individuals (11 13 19)

More striking however was the comparison between the blood levels resulting from a single dose of sulfadiazine during labor and those attained in the same patients after identical intervals in the early puerperium. The concentrations of sulfadiazine in the blood in the latter series were on the average 5.5 times as high as those occurring during labor

In contrast to the rather uniformly poor absorption of sulfathiazole and sulfadiazine during labor the results with sulfanilamide showed a greater range of variability. The majority of the patients conformed to the standard type of absorption curve in only 4 of the 16 cases were the blood levels conspicuously low. The cause for the greater irregularity of absorption of sulfanilamide during labor is not clear. However when complete absorption curves for these same 4 patients were established during the puerperium the blood concentrations were found to rise to the same general levels as are normally encountered in nonpregnant individuals receiving similar doses of the drug

No explanation for the anomalous absorption of the sulfonamides from the gastrointestinal tract during labor is completely satisfying. Marshall and his associates (7 8) have shown that sulfanilamide and sulfapyridine are very poorly absorbed from the stomach. When the drugs were introduced into the stomachs of dogs after the pylorus had been ligated very little of the sulfonamide appeared in the blood. When the drugs were

permitted to pass into the duodenum, however a sharp rise promptly occurred in the blood levels. There is some evidence (3 3) that the emptying time of the stomach may be prolonged at least in some patients, during labor. This might account, in a measure for the poor absorption of the sulfonamides. Moreover sulfapyridine has been claimed to exert a specific delaying effect on the emptying time of the human stomach (9). Thus the differences among the blood levels of the sulfanilamide sulfathiazole and sulfadiazine treated patients may be related to varying effects exerted on gastric emptying by each of these compounds.

The group of patients receiving sulfadiazine were all given small doses of scopolamine (up to 1 milligram) during labor as a part of their analgesic medication. Because of the similarity of action between this drug and atropine the rôle of the former in prolonging the emptying time of the stomach was taken into consideration. However despite the claims for an inhibitory effect of atropine on the emptying of the stomach (5 18) a most careful study of the effects of this substance in the human has shown it, in doses up to 2 milligrams, to produce no significant alteration in the gastric emptying time (4). Moreover the patients in the sulfathiazole series received no scopolamine yet their failure to absorb the drug was even more striking than in the case of those patients to whom sulfadiazine had been given. The effects of scopolamine may therefore be eliminated from consideration.

Whatever may be the factor or factors responsible for the low blood concentrations of the sulfonamides following their oral administration during labor the therapeutic implications of this study are perfectly clear. Oral therapy cannot be relied upon especially with sulfathiazole and sulfadiazine to establish effective blood levels of these drugs during labor. When prompt therapeutic action is desired parenteral administration of these drugs should be resorted to. Indeed, it has been found that when sodium sulfathiazole or sodium sulfadiazine is administered intravenously during labor a single dose of 5 grams (100 cubic centimeters of a 5 per cent

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solution) results in an immediate blood level of approximately 20 milligrams per cent (16) Effective blood concentrations persist for at least 6 hours with sodium sulfathiazole and perhaps twice as long with sodium sulfadiazine This latter finding clearly relates the low blood levels following oral therapy to faulty absorption rather than to increased rate of excretion during labor

The high blood levels attained after the intravenous administration of the soluble sodium salts of sulfathiazole and sulfadiazine have also made possible the prompt establishment of therapeutic concentrations of these drugs in the fetal blood Results of the studies on the placental transmission of the sulfonamides will be described elsewhere (16)

## SUMMARY

Three groups of women were given a single large dose of sulfanilamide, sulfathiazole, and sulfadiazine, respectively, during labor In contrast to the therapeutically effective blood levels ordinarily resulting from the administration of similar doses of these drugs, markedly impaired absorption, as indicated by extremely low blood concentrations, occurred during labor This anomalous absorption during labor occurred rather uniformly among patients receiving sulfathiazole and sulfadiazine, but was noted in only 4 of 16 patients to whom sulfanilamide had been given When similar doses of sulfanilamide and sulfadiazine, respectively, were administered to the same patients during the puerperium, prompt absorption, with the establishment of effective blood concentrations, was observed Sodium sulfathiazole and sodium sulfadiazine, injected intravenously during labor in similar doses resulted in immediate high blood concentrations, which were maintained at therapeutically effective levels for at least 6 hours in the case of the former and considerably longer in the case of sodium sulfadiazine

## CONCLUSIONS

- 1 Orally administered sulfonamides are poorly absorbed from the gastrointestinal tract during labor
- 2 When prompt chemotherapeutic action is required during labor, these drugs should be given by parenteral injection

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# THE DIAGNOSIS AND TREATMENT OF TUBERCULOSIS OF THE KIDNEY

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**E**VERY urologist agrees with the statement that genitourinary tuberculosis is secondary to a distant focus of tuberculosis, and because of this fact he is interested in the general subject of tuberculosis.

Since 1900 there has been a definite downward trend in the mortality from tuberculosis. In 1900 the death rate was 202 per 100,000 and in 1940 it was 45.7 per 100,000 an improvement of 77.36 per cent. The current indications are that when the final reports for 1941 are tabulated the death rate from tuberculosis for the United States will be less than 45 per 100,000 total population. The improvement will be more than 2 per cent over 1940 when according to provisional reports, the death rate was 45.7 per 100,000. In 1940 twelve of the states of the Union had death rates from tuberculosis below 30 per 100,000 and six of them had death rates of 20 per 100,000 or less. (10) This downward trend since 1900 is shown in Figure 1.

We may pause for a moment to compare these figures with the accidental deaths in 1941 which were 76.2 deaths per 100,000 of our population, and with motor vehicle deaths for 1941 which were 30 per 100,000 (7).

It is but natural that this marked reduction in the mortality in general tuberculosis should be followed by a marked reduction in the incidence of renal tuberculosis and this is the experience of many urologists including myself. In 1923 (8) I reported a series of 221 cases of renal tuberculosis and in 1936 (9) a series of 43 cases of renal tuberculosis occurring in childhood and adolescence. This paper is based on a study of 95 cases that have been under my personal supervision since the previously mentioned publications.

The pathogenesis of tuberculosis as it affects the kidney has been surrounded with a new

conception in the past several years. Heretofore there have been 5 theories regarding the routes of infection in renal tuberculosis: (1) hematogenous (2) urogenous, via the lumen of the ureter (3) lymphogenous, via the perireteral lymph vessels (4) direct extension from surrounding areas, such as the bowel (5) extension through the diaphragm from the lung. Today our thoughts as to the pathogenesis of renal tuberculosis are practically limited to the belief that the cause is infection by the hematogenous route and the fixation of tubercle bacilli in the tissue (3).

The primary infection in tuberculosis is usually through the respiratory tract. But this primary infection does not allow the fixation of tubercle bacilli in organs or tissues until sensitization to the bacilli and their specific toxins has had an opportunity to develop. The time interval from the primary infection to the development of the sensitization in the tissues of the body varies approximately from 10 days to 4 weeks. During this interval, that is prior to the development of the sensitization the tubercle bacilli may wander through the body in one or another of the vascular channels. However, with the development of sensitization when they come in contact with tissue structure the reactivity of tissue cells, developed in the process of sensitization causes an outpouring of serum which fixes the tubercle bacilli at that site. Therefore if in the wanderings of these organisms they happen to pass through the kidney when sensitization is developing or has already developed, the bacilli may become fixed in the kidney. Some of the organisms thus fixed may through phagocytosis, be engulfed or destroyed, or they may lie dormant, surrounded by fixed tissue cells in the structure where they have been deposited awaiting reactivation in these tissue cells to permit bacillary growth and pathological change in the kidney.

## HEMATOGENOUS DISSEMINATION OF TUBERCLE BACILLI

The conditions under which hematogenous dissemination of tubercle bacilli may occur are as follows

- 1 Primary infection prior to the development of sensitization

- 2 A state of anergy or loss of sensitization which may sometimes occur even after sensitization has been developed This again allows a migration of tubercle bacilli until a new sensitization develops

- 3 Intimal tuberculosis which will sometimes develop incidental to the deposition of tubercle bacilli in a contiguous part As the bacilli grow into tubercles and penetrate that wall they may discharge tubercle bacilli from their caseous center into the circulation itself, to be filtered out and fixed in a sensitized tissue like the kidney

- 4 The entrance of tubercle bacilli into the blood stream where they undergo hematogenous dissemination The tubercle bacilli may reach the blood stream through mechanical rupture of the caseous node, either in a hilar lymph gland or in a caseous pulmonary lesion, or, at times, through tuberculous salpingitis or tuberculous prostatitis In the latter the usual pathological picture is that of a miliary dissemination either pulmonary or generalized

*Sex* In my experience there was practically no difference in the sex incidence in this series of cases or in the previously reported cases, therefore sex has no diagnostic value In this series there were 46 males and 49 females

*Age* As is well known, tuberculosis of the kidney occurs most frequently in the prime of life In my experience the largest number of cases occurred in the third decade The youngest patient was 10 years of age and the oldest, 66 In a total of 95 cases the age distribution was as follows 10 years of age, 1 patient, 11 to 19 years, 7 patients, 20 to 29 years, 14 patients, 30 to 39 years, 34 patients, 40 to 49 years, 26 patients, 50 to 59 years, 8 patients, 60 to 69 years, 3 patients, age not stated, 2 patients

*Sides* Whether the disease occurs more frequently on the right or left side is of little value in diagnosis and treatment and has an

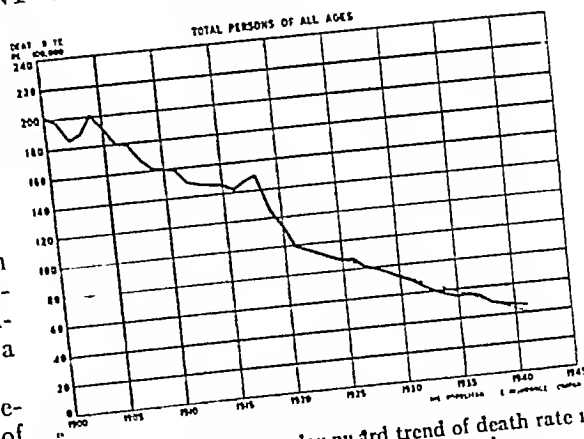


Fig 1 Chart showing downward trend of death rate in tuberculosis from 1900 to 1940, 1941 estimated

academic interest only Of much more importance is the question whether the tuberculosis is unilateral or bilateral, since this has a direct bearing on the question of treatment and may raise the question of the surgical removal of one of the two diseased kidneys

It was formerly believed that bilateral involvement was uncommon, however, with more careful study it has been demonstrated that instead of being rare it occurs relatively frequently It is my opinion that the more carefully the examination is made, the larger will be the number of bilateral cases In my first series, 19.3 per cent disclosed bilateral tuberculosis, in the second series 37.2 per cent in 43 cases, and in the present series there were 22 cases or 23.1 per cent These figures reveal a higher incidence of bilateral tuberculosis than the impression one gains from the literature where it is very frequently stated that bilateral involvement in renal tuberculosis is not very common The right side was involved in 42 cases, or 44.2 per cent, the left side in 31 cases or 32.6 per cent

*The presence of pulmonary involvement* In view of the fact that tubercle bacilli gain entrance to the body in the largest number of instances via the respiratory tract, examination should include, as a matter of routine, roentgenograms of the chest For various reasons roentgenograms were not obtained in each case of this series, but roentgen reports were available in 50 cases with the following results positive active lesions in 6 cases, or

12 per cent positive old healed lesions in 19 cases, or 38 per cent and negative findings in 25 cases, or 50 per cent. In other words, of 50 patients examined with roentgen rays one half or 50 per cent, of them disclosed evidence of pulmonary tuberculosis, either active or healed. In my previous series of adult cases published in 1929 the percentage of positive findings was 35.5. In the second series of 43 cases the incidence was 37.2 per cent and in this series 50 per cent, thus showing a very definite increase in the number of cases in which chest roentgenograms were positive.

*Other tuberculous lesions.* A review of the records discloses that 37 patients or 38.04 per cent practically 39 per cent, had evidence of tuberculosis in other parts of the body either present at the time the patient came under observation or it was noted in the history that the patient had been operated upon or had been treated for tuberculosis. Interesting in the study of this group of cases was the large number of patients with genital tuberculosis and the small number with glandular or bone tuberculosis.

#### DIAGNOSIS

In the largest number of instances when a patient consults the urologist the diagnosis is easy and it is based on the demonstration of pus and tubercle bacilli in the urine obtained from the kidney with the ureteral catheter. With a history of antecedent tuberculosis (lungs, glands, bones, genitalia) associated with a history of urinary symptoms, often diagnosed and treated as cystitis with out relief plus the presence of pus and tubercle bacilli in the urine the diagnosis of urinary tuberculosis is established. Then there remains the problem of localizing the lesion whether present in one or both kidneys or whether the urinary tuberculosis is secondary to tuberculosis in the prostate or vesicles, or in both. A plain roentgen ray film of the urinary tract is next in order to rule out the presence of stone and to note the presence of calcification. Stone associated with tuberculosis is uncommon.

In one of our cases in which there were no urinary symptoms the patient came in with a typical history of renal stone. The urine was

negative at the time of admission and the x ray film and intravenous urogram disclosed a stone in the pelvis and a large hydronephrosis. No search for bacilli was made. After the kidney was removed the presence of tuberculosis was found (Fig. 2).

Areas of calcification when present are of diagnostic importance. However in my experience they have not been seen very often and when present were in advanced cases. I recently saw a man of 62 years with extensive calcification due to renal tuberculosis, who because of his marked urinary symptoms was sent in with a diagnosis of prostatic hypertrophy (Fig. 3).

In an occasional case the film may show the outline of the enlarged kidney with more or less rounded areas of increased density due to the presence of inspissated pus (pus) kidney).

*Intravenous urography.* With the wide spread use of intravenous urography there is a certain tendency to rely upon its use to the exclusion of ureteral catheterization in the diagnosis of renal tuberculosis as well as in the determination of the status of the opposite kidney. I am sure many urologists have had the experience of finding tubercle bacilli and pus cells in the catheterized specimen from a kidney which was reported as normal on the basis of the intravenous pyelogram. I believe this source of error is much more common than is generally appreciated. Thus Emmett found tubercle bacilli in the urine of 26 per cent of his patients in whom the intravenous pyelogram was reported as normal. Therefore one should not accept the results of intravenous pyelograms alone to determine whether or not the opposite kidney harbors tuberculosis. In other words, if in a given case tubercle bacilli have been found in bladder urine and an intravenous urogram discloses a pyelogram on one side which is compatible with renal tuberculosis we have another link in the chain of evidence (Figs. 4 and 5). However if the pyelogram on the opposite side is reported as normal, we must not assume that such is the case without careful study of the urine obtained by ureteral catheterization.

Bugbee has recently reported an interesting case in which the pyelogram revealed a filling



Fig 2 Dilatation of the bifid pelvis, and hydronephrosis of the upper half of the kidney due to a large stone in the pelvis of the kidney. The tuberculosis was found in the lower half of the kidney



Fig 3 Extensive calcification in the left kidney due to tuberculosis

the ureteral orifice. In the advanced cases, extensive involvement with limitation of bladder capacity is noted.

It has been my practice for many years to exercise great precaution against the so called "possibility" of infecting the normal kidney by the ureteral catheter carrying infected urine up the ureter. This can easily be avoided by plugging the end of the catheter with a large pin.

In some of the cases one cannot catheterize both ureters because of severe and extensive bladder involvement, thus making it impossible to find one or both orifices. Again it may be impossible to catheterize the ureter because of the presence of a stricture. In this series of 95 cases, there were 25, or 26.31 per cent, cases in which it was not possible to catheterize the diseased side.

#### *Demonstration of tubercle bacilli in urine*

As one's experience grows, a tentative clinical diagnosis is made more and more frequently, so that search for bacilli is more and more mandatory and the percentage of cases in which bacilli are found in the urine increases from year to year. If, for example, from the history one suspects tuberculosis and tubercle bacilli have been found in the bladder urine, a most careful search should be made in the kidney specimen by smear. On the other hand, in cases in which one does not have any suspicion that the patient has tuberculosis,

defect compatible with tumor. The filling defect was due to a tuberculoma. In one of my recent cases a tuberculoma was found, which, however, did not produce a filling defect compatible with tumor (Fig 6).

*Cystoscopic examination and ureteral catheterization.* Next in order is the cystoscopic examination and ureteral catheterization. Our objective should be to make an absolutely correct diagnosis with as few cystoscopic examinations as possible, in other words, repeated instrumentation should be kept at an absolute minimum. Every attempt should be made to obtain all the necessary information at the first cystoscopic examination.

The information and limitation of the cystoscopic examination and ureteral catheterization depend upon the duration of the renal tuberculosis. In the early cases the bladder may be normal. In some cases changes in the ureteral orifice itself are seen, in others the presence of tubercles is noted in the region of



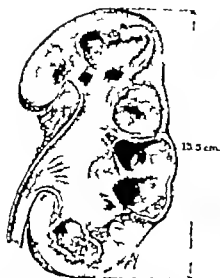


Fig. 4. Extensive involvement of the kidney. Intracapsular pyelogram in this type of case is always the most informative.

but does not want to overlook the possibility of tuberculosis, then all 3 of the methods—namely smears, cultures and guinea pig inoculations—should be used.

Tubercle bacilli were found in 81 or 85.28 per cent, of the 95 cases, by smears or cultures or guinea pig inoculations, or else by all 3 methods, in 2 of which cases bacilli were demonstrated in the pus from a draining sinus, the patients having previously been operated upon for perirenal abscess. In 13 cases, or 13.75 per cent the diagnosis was made by cystoscopy and by pyelograms. In 1 case the diagnosis was made at operation, as heretofore mentioned.

I would like to call attention to a group of patients in whom the diagnosis may be and sometimes is, overlooked. They give no history of antecedent tuberculosis, there are no urinary symptoms, and they are sent in because of the presence of albumin and pus in the urine which has resisted the usual treatment. They may have sets of intravenous urograms which reveal hydronephrosis and the request is made that ureteral dilatations be given.



Fig. 5. Intracapsular pyelogram is most informative in cases of this type showing advanced renal tuberculosis. Note the increased deposit of fat. Regarding fibroplasia (?)

It should not be overlooked that it may so happen that the urine in a patient with renal tuberculosis may be clear and free of pus when he presents himself. Nevertheless, in a case of this sort or whenever the least suspicion arises in my mind as to the underlying pathological condition, I routinely use all 3 methods—namely smears, cultures, and guinea pig inoculations.

In patient a diagnosis of stricture in the superior calyx with hydronephrosis was made from the pyelogram however careful study of the smears showed tubercle bacilli. A nephrectomy was performed. Examination of the specimen disclosed that the hydrocalyx was due to tuberculosis and not to a simple stricture (Fig. 7).

When a patient has been operated upon for drainage of a perirenal abscess and if the sinus does not heal in a reasonable period of time one should always be suspicious that the underlying pathology may be renal tuberculosis. Examination of the pus which came from the draining sinus in the loin in 2 recently studied cases disclosed the presence of tubercle bacilli.

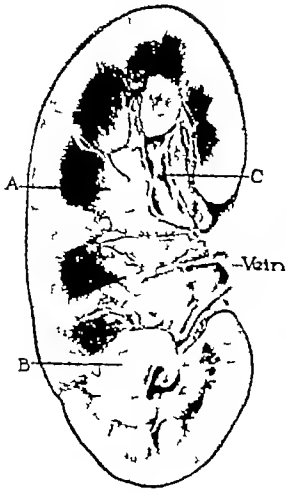


Fig 6

Fig 6 A, Tuberculosis in a papilla, B, tuberculoma, C, submucous hemorrhage. Filling defect was not compatible with tumor



Fig 7

Fig 7 Tuberculous hydrocalyx

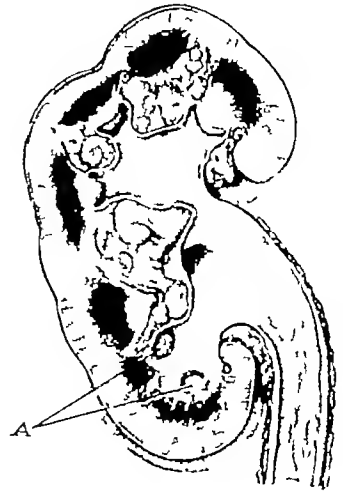


Fig 8

Fig 8 Early lesion which may be missed with an intravenous urogram

**Retrograde pyelography** There are some sharp differences of opinion regarding the use of retrograde pyelograms in the diagnosis of renal tuberculosis. Some urologists have used pyelograms in all cases, have repeated them as often as necessary, and have never seen any bad effects. On the other hand, there are other urologists who caution against the routine use of retrograde pyelograms because of the danger of pyelovenous backflow. In order to study the course of the disease Thomas repeats the pyelograms as often as necessary, whereas Hinman states that the urologist who requires a pyelogram to show defects in filling caused by tuberculosis in order to complete his diagnosis, is not sure of himself. In my opinion there exists a happy medium between these two points of view. I do not make retrograde pyelograms as a routine, reserving them for cases in which the intravenous urogram has been reported as normal, and the examination of urine from the supposedly normal kidney discloses the presence of pus cells. Then a retrograde pyelogram is justifiable. Furthermore, in cases in which the tuberculous lesion is very small (Fig 8) and an intravenous urogram is inadequate to show its presence, a retrograde pyelogram should be of considerable value.

Once the presence of tubercle bacilli and pus have been demonstrated in the urine obtained from the kidney by ureteral catheter, a retrograde pyelogram is unnecessary, since it is of no help in establishing the diagnosis of renal tuberculosis. However, if a few pus cells and a few tubercle bacilli are found in the so called normal opposite kidney or if the urine is clear and reveals a few tubercle bacilli, and if the intravenous urogram is reported as normal, then it is my opinion that retrograde pyelogram should be made. Our objective should be to make an absolutely correct diagnosis of the disease with as few cystoscopic examinations as possible, in other words, repeated instrumentation should be kept at an absolute minimum. Every attempt should be made to obtain all the necessary information on the first cystoscopy.

#### TREATMENT

Once the diagnosis of renal tuberculosis has been established the treatment is nephrectomy. Renal tuberculosis as seen by the clinician does not heal. This statement bears repetition since the idea seems to prevail among some physicians that renal tuberculosis can be cured by means of medical treatment and thus nephrectomy can be avoided. I have never

seen a case of proved renal tuberculosis heal under medical treatment.

Healing as such is not to be confused with cases in which a tuberculous stricture of the ureter completely occludes the ureter and the urine becomes clear and is free of pus. When this occurs the condition has been referred to as autonephrectomy. This does not constitute healing in the strict sense of the term since tubercle bacilli have been found in these kidneys after their removal. Whether or not this type of patient should be operated upon has been the subject of discussion pro and con. I have not operated upon a patient with this type of renal tuberculosis.

In the light of our present knowledge of the relationship between unilateral kidney disease and hypertension, removal of this type of renal tuberculosis may be considered. However one must be mindful of the fact that the removal of the kidney may not influence the hypertension.

Nephrectomy for renal tuberculosis is never an emergency operation. There is always plenty of time to await the results of the guinea pig inoculations as well as the results of the cultures if there is any doubt about the question of involvement of the opposite kidney. One always has plenty of time for a careful study of the patient for the presence of other foci of tuberculosis and for the institution of preliminary preparation of the patient. In the ordinary case as seen by the average urologist this period is short. I can not agree with the view that all patients with renal tuberculosis should have sanatorium treatment for at least 6 months before the nephrectomy. In institutional practice where so many patients are seen with multiple active foci and far advanced lesions, preliminary treatment is in order. In the average case treatment before operation should not be carried out too long since it may forego the optimum time for the operation, and there is also the possibility of spread to the other kidney which one must watch.

I will not enumerate the technical details except to say that there has been endless discussion in regard to the treatment of the ureter varying from complete removal down to the bladder to removing as much of the ureter

as can be done through the incision, or to sewing the cut end into the skin the latter procedure has recently been re-emphasized by Howard. My procedure is the removal of as much of the ureter as can be conveniently removed.

Equally as important as the operation itself is the postoperative program a fact which I hardly need stress before this group. With the necessity for a postoperative program I am in hearty accord.

Nothing is so disturbing both to the patient and the physician as the persistence of bladder symptoms following nephrectomy. Their severity and duration are directly dependent upon the extent of bladder involvement which in turn is dependent upon the duration of renal tuberculosis before operation. In other words, in early cases with little or no bladder involvement this problem does not exist. In advanced cases with extensive bladder involvement the persistence of bladder symptoms constitutes a problem of considerable magnitude.

I do not resort to local treatment. It is my experience that no matter which form of local treatment is used the procedure is painful and rarely shortens the duration of the bladder symptoms. The internal use of methylene blue has its advocates, and apparently gives relief in a large number of cases.

*Bilateral tuberculosis.* Views on the question of nephrectomy in bilateral renal tuberculosis change from time to time and depend largely upon the views of the individual urologist. Henline recently reported a series of 40 cases of bilateral tuberculosis in which he performed a nephrectomy on 29 patients. As a general rule I refrain from nephrectomy in these cases since removing one tuberculous kidney can have no healing or curative effect upon its mate. However there are circumstances under which one is obliged to operate—for example when one side discloses a pyonephrosis that results in acute septic manifestations—chills, fever, sweats, high leucocyte count—one is obliged to do a nephrectomy—but in this instance the kidney is removed primarily because of septic infection with septic manifestations and not on account of renal tuberculosis.

presuppose that tubercle bacilli are deposited there without production of a permanent or demonstrable infection in the vagina or uterus. In the tubes the bacilli gain a foothold and multiply in the folds of the mucous membrane. In the uterus the mucous membrane, as a result of menstruation, is continually exfoliating and regenerating thus providing the tubercle bacilli with less favorable living conditions.

Some of the cases described in the literature as a primary genital tuberculosis were based on autopsy findings. Amann (2) and Feis rightly point out that old healed primary foci may have been overlooked in these cases. The majority of cases reported are clinical and their findings are frequently limited to examination of biopsy specimens of the adnexa or endometrium.

It is our opinion that primary tuberculosis of the female genital organs rarely, if ever, occurs. In no case described in the literature, including the reports of postmortem examinations, were the criteria of a primary complex found, i.e., the genital tuberculosis was the first infection in the body and the regional lymph nodes showed the same stage of anatomic development as the involved genital organ.

#### *Direct extension from a neighboring organ*

In 26 of the 52 individuals, or 50 per cent, there was an accompanying tuberculous peritonitis. Heimann reports it in about 65 per cent of the cases, Pankow, an incidence of 54 per cent, and Wolff, 68.3 per cent. Direct infection from the peritoneum could be possible in only half of our cases.

This mode of infection has been a point of much controversy in the literature. Are the tubes involved secondarily from, (1) a tuberculous peritonitis by direct extension to the serosal surface (continuity), or through the patent fimbriated end of the tube (contiguity), or (2) by extension of the process from the tubes to the peritoneum?

Infection by continuity is definite only when one can ascertain that the involvement began on the peritoneal surface and extended toward the mucosa in the presence of a decreasing intensity of the tuberculous process as the latter is approached. In determining



Fig 1 Tubes and uterus. Both tubes are markedly thickened and tortuous. The left tube, *a*, which is open is filled with caseous material. Note the marked fibrosis covering the unopened tube, *b*. The lumen of the uterus is dilated and is lined by a caseous zone, *c*.

the course of extension of the process in our cases, we deleted those cases in which the process was uniformly extensive from the mucosa to the peritoneum. In the remaining cases, the process was most extensive in the mucosa and decreased in intensity toward the serosa. This on first thought appears to favor the development of the process by contiguity from the peritoneal cavity. However, we found the first tuberculous foci developing within the wall of the tube and not in the lumen and also, in these cases, there was no peritoneal tuberculosis.

*Lymphatic extension from a near or distant focus.* This mode of extension is promulgated by Amann (2) and Pozzi. We have seen no evidence of a lymphatic extension of genital tuberculosis in our cases. In an infection disseminated by lymphatic drainage one should be able to observe a tuberculous process in the lymphatic vessels and lymph glands along its route. This is not true as in our cases lymph node involvement was usually limited to the regional glands draining the diseased portion of the genital tract.

*Hematogenous origin from a distant focus.* We believe the controversy in the literature as to pathogenesis arises from attempts to determine the origin of far advanced cases. It is only in the early stages of the process that such a study can be made.

Six cases of tubal tuberculosis presented early lesions. In all cases, tuberculous foci were present in both tubes and were located in the submucosa and the mucosa. In these cases older foci were present in the lungs,



Fig. 2.



Fig. 3.

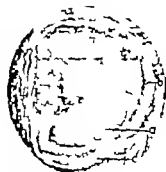


Fig. 4.

Fig. 2. Photomicrograph of an early tuberculous process in the tube. A tuberculous focus in the submucosa has perforated into the lumen of the tube. The resultant ulcer lined by a zone of coagulation. The remainder of the tube the epithelial lining is intact. *b*.

Fig. 3. Photomicrograph of an advanced tuberculous process of the tube. The lumen of the tube and the inner wall contain caseous material. The outer portion of the wall is intact. *b* is intact.

Fig. 4. Photomicrograph of a far advanced healing process in the tube. The lumen of the tube is filled with caseous material, which contains calcified particles. *b* top and the outer aspect. Surrounding the zone of coagulation is a concentric zone of hyalinized connective tissue. *c*, which in turn is followed by atrophic.

Fig. 5. Photomicrograph of an early tuberculous process in the uterus. The ulcer is limited to the lower portion of the endometrium and contains giant cells. Note the endometrial gland. *b*.



Fig. 5.

there was no tuberculous peritonitis, and the foci present were unassociated with the lymphatics.

In 5 cases there were hematogenous foci of similar anatomic age in other organs. In 1 case the tubes and the lungs, only, revealed tuberculous pathology.

When do hematogenous seedlings of the tubes occur? These seedlings occur when any tuberculous process in the body drains into the blood stream. We found the hematogenous seedlings to the tubes occurring in the presence of (1) a primary complex (2) an extrapulmonary tuberculosis and (3) a chronic pulmonary tuberculosis.

1. Ten cases revealed hematogenous seedlings in various organs and a fresh healing or healed primary complex. Most of these cases were observed in children (3 at 2 years of age). Tubal involvement occurs during the active stage of the primary complex when tubercle bacilli from the caseous lymph nodes drain

into the blood stream. The primary complex and the hematogenous foci in other organs may undergo healing while the process in the tubes progresses. The lesion in each instance in this group was a caseous process.

2. In 3 cases the tuberculous process was associated with an active extrapulmonary tuberculosis (3 of tuberculosis of the vertebrae and 1 tuberculous meningitis). In 3 of the cases, including the case of concomitant tuberculous meningitis, miliary foci were discovered in the walls of the tubes on microscopic examination and were part of a terminal hematogenous dissemination. In the fourth case a caseous involvement of the tubes, as of more recent origin than the extensive tuberculous process in the vertebrae.

3. Thirty-five cases occurred in the presence of chronic pulmonary tuberculosis. In some cases particularly those in the adolescent age the chronic pulmonary tuberculosis was of a more recent origin than the tubal

lesion, thus it is likely that in these the tubal involvement developed from the primary complex. In those cases revealing both advanced pulmonary and tubal disease it is difficult to establish priority of involvement. In most cases the tuberculous process in the tubes was of shorter duration than that of the chronic pulmonary tuberculosis. The involvement of the tubes was a result of a hematogenous dissemination from the lungs. It is interesting, that with the frequent hematogenous seedings occurring from chronic pulmonary tuberculosis (as evidenced in the spleen and kidneys) foci were not found more frequently in the tubes. The early foci were first discovered on routine microscopic examination. There is no doubt that if serial studies had been made or if numerous sections had been studied microscopically, the incidence of tubal tuberculosis would have been much greater.

*Distribution* Of the 49 cases in which the tubes were involved both tubes were involved in 46. There are two explanations for a unilateral hematogenous infection. Early cases, without gross tuberculous changes, may be considered negative without serial sectioning, and it is also possible that one tube may progress while the other undergoes anatomic healing.

*Gross appearance* The tuberculous process first develops in the abdominal ends. In the early stage of the disease the form, size, and shape of the tubes are not altered, and the diagnosis of tuberculosis can be made only on microscopic examination. As the tuberculous process develops, the diameter of the tube becomes progressively greater. Pankow points out that a slightly thickened superficial surface of a tube in the absence of nodules in the wall cannot be differentiated from any septic tube. In most cases the tuberculous process does not develop evenly throughout the tube, the abdominal end showing the greatest changes and the uterine the least. As a result of this uneven distribution of the process the tube has a nodular and often a tortuous appearance.

The serosal surface may be smooth, and especially in the early cases the disease is limited to the inner tube, this is true also in

late cases in which the process has not extended to the outer portion of the wall. These tubes lie free in the abdominal cavity. As the tuberculous process progresses the tube becomes softer in consistency and on cross section the inner wall is caseated. In the later stages the lumen is completely obliterated by caseous material or it is markedly narrowed and the mucosal folds stand out as thick pads of caseation. In this stage of development the muscular layers of the tube are usually intact although occasionally the caseous process may involve it. The fimbriated end of the tube is occasionally patent but more often it is occluded by the caseous process.

In the more extensive processes, when the caseation involves the entire wall, the serosal surface is studded with various sized caseous foci and intervening patches of fibrin. The development of the tuberculous process on the serosa results in a matting together of the tubes with the uterus, ovaries, mesentery or intestines or both.

*Microscopic examination* The development of the tuberculous process in the tubes has been described in two ways. Huebschmann is of the opinion that the first stage of the process is a "bacillary catarrh," first described by Schramm and elaborated upon by Simmonds. The tubercle bacilli brought by the blood stream are excreted into the lumen of the tube and the first changes develop here. In the second mode of occurrence the tuberculous process first forms in the wall of the tube.

In "bacillary catarrh" swelling of the mucous membrane and a partial hyperemia of the folds occur. Lying in the lumen is a typical purulent exudate containing many polymorphonuclear leucocytes. Leucocytes and lymphocyte-like cells are present in the mucous membrane. In some areas there is a desquamation of the epithelium, but it is for the most part intact. The remaining layers show only a hyperemia.

In postulating "bacillary catarrh" one must assume that the tubercle bacilli, brought by the blood stream, may pass through the wall of the tube without causing a tuberculous lesion in passage. To accept definitely the presence of "bacillary catarrh" one must as-

certain that no older focus is present in the submucosa or mucosa which may have extended through the latter into the lumen. After perforation into the lumen the bacilli will then produce the picture of bacillary catarrh. In other portions of the tube it is, therefore necessary to section the tube serially to rule out older foci in the wall. This was not done by Huebchmann or Simmonds.

The other mode of development accepted by most authors and observed by us in the early development of the process is the early formation of foci within the wall of the tube. Tubercle bacilli brought by the blood stream form tubercles within the wall wherever they are deposited (usually in the submucosa). Some have a caseous center. The caseous foci as they progress, either involve the overlying mucous membrane in the tuberculous process or they cause a pressure atrophy of the mucous membrane. After liquefaction the caseous foci pour their bacilli into the lumen and form an ulcer at this site. The ulcer is lined either by a zone of caseation or a pyogenic membrane. Beyond the inner zone is an area of vascular granulation tissue containing epithelioid and giant cells. The ulceration is limited to the submucosa and the remainder of the wall shows no evidence of tuberculous change.

In this stage of development adhesion of the individual folds of mucous membrane may result in formation of large cyst spaces which has been termed 'pseudofollicular salpingitis'. We observed 1 case in our series.

The anatomy of the tube because of the numerous folds in the mucous membrane is ideal for the further extension of the process. The tubercle bacilli poured into the lumen after the caseous foci have perforated through the mucous membrane stimulate the production of a specific exudate composed of polymorphonuclear leucocytes, serum, fibrin, red blood cells, and desquamated epithelial cells. It is only the presence of acid fast bacilli which differentiates this exudate from one produced by other organisms.

The exudate within the lumen undergoes caseation and in the early stages some of the cells of the exudate may still be intact. Bathing of the mucous membrane by tubercle

bacilli causes a progressive caseation of the wall toward the serosa. The former structure of the wall as well as the exudate in the lumen is still discernible within the area of caseation. Beyond the caseous area is a zone of tuberculous granulation tissue.

With its progression toward the serosa an inflammatory exudate develops on the serosal surface which is invaded by granulation tissue with a resultant matting together of tubes and the surrounding structures. The caseous process arising in the tube may extend beyond the serosa to involve the peripheral portions of the adjacent organs, especially the ovaries and infrequently the intestines.

*Healing.* As in tuberculosis in other organ the process in the tubes may undergo anatomic healing. Huebchmann reports spontaneous healing in all stages of development in autopsy material. Williams never saw healing with calcification in the tubes because his observations are based chiefly on operative specimens in which late manifestations of the disease are not as frequently encountered.

We observed healing changes in the tubes in 3 of our patients. In 2 cases the tubes revealed the only genital lesions. In the third case there was also involvement of the uterus. In none of these instances did the peritoneum show evidence of pathological change.

In 1 patient in whom the only genital tuberculosis was in the tubes healing of the tuberculous foci occurred before they ruptured into the lumen. The foci were present at the abdominal ends of the tubes within the submucosa and inner portion of the muscularis, and on microscopic examination revealed both encapsulated caseous calcified areas and miliary tubercles without caseous centers.

Healing in a second case occurred in an advanced stage of the tuberculous process in which the tubes were enlarged tortuous, firm in consistency, and cut with a grating sensation. On cross section almost the entire tube was occupied by firm caseous material containing large deposits of calcium. This central caseation was demarcated from a narrow rim of muscularis by a white capsule.

Microscopically this form of healing shows purple granular deposits (calcium) laid down irregularly within the caseation. The zone of

vascular granulation tissue beyond the caseation is transformed into a concentric zone of hyalinized connective tissue. The small tuberculous foci in the remainder of the wall are similarly transformed into hyalinized connective tissue.

The tubes in the third patient were embedded in fibrous tissue and adherent to the ovaries distally. The walls of these tubes were thinner than normal, their lumina were patent, and on cross section there was an increase of fibrous tissue. A diagnosis of tuberculosis could not be made on gross examination.

Microscopically, however, there was a proliferation of the specific elements beginning in the zone of caseation and finally completely replacing it, and as healing continues the collagen fibrils predominate in both the inner zone of caseation and the area of granulation tissue. Our case showed this stage of development. In the final stage the collagen fibers fuse to form an area of hyalinized connective tissue.

#### UTERUS

The uterus was involved in 29 cases, or 55.7 per cent. The incidence previously reported varies from 44 per cent (Merletti) to 76.3 per cent (Simmonds). Twenty-six of the 29 cases of uterine tuberculosis (or 89.6 per cent) were concomitant with tubal tuberculosis. Simmonds reports an incidence of 65 per cent, Pankow, 31 per cent, and Schlimpert, 38 per cent. Our higher incidence may be explained by the fact that we made microscopic studies of uteri in our cases. In 6 of our patients the tuberculous lesion was discovered on microscopic examination and in each there was an older tuberculous process in the tubes.

There are 4 possible modes of infection of the uterus: primary infection from the outside, lymphatic extension from a near or distant tuberculous process, hematogenous infection from a distant focus in the body, descending infection from the fallopian tubes.

*A primary infection from the outside.* This mode of infection is similar in all respects to the discussion presented for the fallopian tube.

*A lymphatic extension from a near or distant tuberculous focus.* R. Schroeder reports 1 case as exemplifying this mode of infection but overlooks an associated tubal tuberculosis.

No case of lymphatic tuberculosis of the uterus appears in the literature.

*A hematogenous infection from a distant focus in the body.* Three cases of this developmental form of tuberculosis occurred in our series. In 2 cases the body of the uterus alone was involved and in the third a caseous focus was present in the inner wall of the cervix, and caseous foci were present in the outer walls of the fallopian tubes. In the 2 cases the foci were present in the outer wall of the body of the uterus and in neither was there evidence of a tuberculous peritonitis. In all 3 cases the uterine involvement was part of a generalized hematogenous tuberculosis.

*A descending infection from the fallopian tube.* It is generally accepted that the majority of cases of uterine tuberculosis is the result of an intracanalicular infection arising in the fallopian tubes. Evidence of this is seen in the decreasing involvement of the tuberculous process from the fundus downward toward the cervix. The process is more advanced in the tubes than in the uterus and progresses along the mucous membrane and rarely extends into the myometrium.

Our own material, as well as the reports of most observers, discloses that, with the exception of those cases resulting from a hematogenous infection, the tuberculosis of the uterus is the result of an intracanalicular progression from the tubes. This is indicated by the fact that the tuberculous process in every instance showed a progressive decrease in intensity from above downward. Moreover, the involvement in the tubes was invariably older than that in the uterus. The tuberculous process extends along the endometrium and only rarely extends into the myometrium.

*Gross appearance.* The size and shape of the organ are unaltered, even in cases of extensive myometrial involvement. Rarely caseous processes in the wall cause its enlargement. A marked enlargement of the organ occurs in those instances in which is an obliteration of the cervical canal by caseous material and resultant accumulation of this material in the uterine canal.

In the very early stages the diagnosis is made only on microscopic examination. The first gross changes observed appear in the



fundus and later in the cervix. The process is more extensive in the fundus, as has been stated, decreasing in amount as the cervix is approached. The cervix is rarely involved.

*Microscopic examination* Microscopically in the early stages an endometritis occurs which cannot be differentiated from any other endometritis. Later the endometrium is replaced by a zone of caseation which decreases in amount from the fundus to the cervix. The caseation is usually limited to the endometrium but it may involve the muscularis.

The earliest stage observed in our series microscopically was one of endometrial caseation. Surrounding the caseous layer is a zone of tuberculous vascular granulation tissue. Occasional tubercles are present in the interstitial tissue between the muscle bundles. These are usually present for a short distance beyond the zone of granulation tissue.

*Healing* The tuberculous process may heal as in the tube (but its occurrence is less frequent). In 1 of our patients healing was evidenced by the invasion and replacement of the zone of caseation by epithelioid cells, collagen fibers, and fibroblasts. The end result of such a process would have been replacement of the zone of caseation by an area of hyalinized connective tissue.

In 2 patients, or 3.8 per cent we found a concomitant involvement of the urinary tract. Both individuals had an ulcerative process in one kidney its pelvis and ureter and occasional small ulcers in the urinary bladder. In both there was also a caseous process in the adrenals and in one there was in addition tuberculous involvement of the spine. Bruening in a review of the literature reports tubercles in the kidneys in 8 of the 44 reported cases of genital tuberculosis in the female. Miliary tubercles in the kidneys are part of a generalized hematogenous seeding as distinguished from an isolated tuberculosis of the urinary system.

#### OVARIES

Ovaries were involved in 15 cases, 28 per cent of our series. Simmonds found involvement in 2.5 per cent, Wolf in 31.7 per cent.

Three routes of infection of the ovary have been described direct infection from the

neighboring structures, lymphatic extension from the tube by way of the ligamentum latum, hematogenous infection from a distant focus in the body.

*Direct infection from the neighboring structures* Frequent involvement of the ovary from the surrounding regions occurs and is described in the literature. In all cases in our series the tuberculous process extended from without into the ovaries. An extensive caseous tuberculous salpingitis was present in 14 cases. In 1 case in our series the tuberculous process extended from the peritoneum to the ovary and in 14 it occurred by direct extension from the tubes. The tuberculous process in the tubes as it progresses results in a serosal reaction (serofibrinous exudate) which in turn causes a matting together of the tubes and ovaries. The caseation in the tubes then extends on to the ovaries.

*Lymphatic extension from the tubes* Schottlander believes that in most instances the ovary is infected through the lymphatic route. This assumption is based on his observations that in his cases of ovarian tuberculosis there was usually an extension from the peritoneum and since the lymphatic vessels extend in this direction he concluded that this route appeared likely.

*A hematogenous infection from a distant focus in the body* Occasional cases have been described in the literature in which tuberculosis of the ovary is present in the absence of tuberculous perioophoritis and they unquestionably resulted from a hematogenous infection.

In all our patients both ovaries were involved by the tuberculous process. To repeat, in 14 cases the tuberculous process developed from an extensive tuberculous salpingitis and in only 1 it developed from a tuberculous peritonitis.

*Gross appearance* There are 2 forms of ovarian tuberculosis. One is an infection of the ovary from without and the other from within. Guillemain designated the former as "perioophoritis" and the latter as "oophoritis."

*Perioophoritis* In this form there is an overwhelming tuberculous process which extends from the surrounding structures (tubes

with one exception) This process is not limited to the ovaries alone but involves all other neighboring structures resulting in a tumor mass After the adherent omentum and loops of intestines are freed, a caseous tubo-ovarian mass is found Rarely are remnants of ovarian and tubal tissue discernible in this caseous mass, except on microscopic examination Liquefaction is frequently present within the caseation Microscopic examination reveals small remnants of tubal and ovarian tissue encircled by caseation Wherever liquefaction is present numerous intact polymorphonuclear leucocytes are found

*Oophoritis* occurs in true cases of hematogenous tuberculosis of the ovary which are rare According to Schlumpert the foci may vary from the size of a pinhead to that of a hen's egg They are present chiefly in the cortex and are most frequently discovered on microscopic examination Microscopic examination shows typical epithelioid giant cell tubercles as well as larger foci with caseous centers Tuberculous involvement of ovarian cyst walls occurs secondarily in a tuberculous oophoritis or perioophoritis

#### VAGINA

The vagina was involved in 2 cases, or 3.8 per cent Schlumpert reports an incidence of 9.6 per cent and Springer, 15.4 per cent There are 4 possible modes of infection direct infection from the outside, infection from the neighboring structures, hematogenous infection from a distant focus, and descending infection from the higher genitalia

*Direct infection from the outside* This mode of infection can be verified only in those cases in which a complete autopsy reveals no other tuberculous focus in the body

*Infection from the neighboring structures* The possibility of an infection from the urinary or the gastrointestinal tract exists The extension may occur through contact infection or by perforation of the process into the vagina To accept such cases, a progressive ulceration from the rectum or urethra to the vagina must be present and reveal a gradually diminished intensity of the involvement as the vagina is approached

*Hematogenous infection from a distant focus* Rare instances of an isolated vaginal tuberculosis are reported in adults (Weigert), most of the cases described occurred in children Kroenig believes that more than  $\frac{2}{3}$  of isolated vaginal tuberculosis occurs in children and this is generally in the first year of life, the usual period of progressive generalization from a primary pulmonary focus

*A descending infection from other genital organs* In our 2 patients the tuberculous process was secondary to, and accompanied by, a tuberculosis of the tubes and uterus In both cases ulcers and foci were limited to the superficial portion of the vagina and were of more recent origin than the process in the uterus and tubes These ulcers were found near the cervix and decreased in size and number distally

The process is one of superficial ulceration associated with elevated yellow nodules chiefly present on the posterior wall The ulcers have an irregular border and vary from 4 to 6 millimeters The inner surface is lined by a yellow or red membrane The yellow nodules vary from 1 to 5 millimeters in diameter, are present between the ulcers, and some, particularly the larger ones, have umbilicated centers

Microscopically the ulcers are shallow and resemble any similar tuberculous ulcer

Foci occur in the wall of the vagina beneath an intact epithelium Some of these foci have caseous centers and, when they rupture through the epithelium, form ulcers

#### CONCLUSIONS

1 In 571 consecutive autopsies in females having tuberculosis, 52 showed tuberculosis of the female genital organs—9.1 per cent

2 The fallopian tubes were involved 49 times—94.2 per cent, the uterus 29 times—55.7 per cent, the ovaries 15 times—28 per cent, and the vagina twice—3.8 per cent

3 Tubal tuberculosis was bilateral in 46 cases, the abdominal ends were first and most extensively involved

4 The tubal tuberculosis was the result of a hematogenous tuberculosis in all of our cases, the hematogenous seedings occurred during a fresh primary complex, from an extra-

pulmonary organ tuberculosis or a chronic pulmonary tuberculosis.

5. The size, shape, and form of the fallopian tubes were not altered in the early stage of the disease as the tuberculous process progressed the tubes became thicker and softer in consistency and on cross section were almost entirely caseous.

6. In the more extensive process a tuberculous peritonitis developed occurring 26 times in our series. The development of the peritonitis resulted in a matting together of the tubes and the surrounding structures.

7. The tuberculous process in the tubes began with the development of foci in the wall which, on perforation into the lumen, caused a spread to the remainder of the tube.

8. Healing of the tubes occurred 3 times, twice with calcification and once with beginning scar formation.

9. Twenty-six of the 29 cases of uterine tuberculosis were the result of an intra-canalicular extension from the tubes the uterus showed decreasing intensity of the process from the fundus toward the cervix. The cervix was infrequently involved by the tuberculous process.

10. The size and shape of the uterus were rarely altered, even in extensive disease. The tuberculous process was usually limited to the endometrium but sometimes extended into the myometrium.

11. In 3 cases the tuberculous process was part of a hematogenous dissemination the foci were present in the wall and were not related to a tubal tuberculosis.

12. In all cases of ovarian tuberculosis both ovaries were involved their involvement was the result of an extension from the surrounding structures (perioophoritis).

13. The vagina was infected from the tubes and uterus and revealed ulcers and nodules which decreased in intensity from above downward.

14. Primary tuberculosis was not present in any of our cases and we doubt its occurrence.

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# SURGICAL STABILIZATION OF DISLOCATED PARALYTIC HIPs

## An End-Result Study

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**A**LTHOUGH paralysis of the muscles of the hip causes considerable handicap, associated subluxation or dislocation produces a much greater degree of disability. External support has not been wholly effective in controlling this additional instability and surgical measures have been resorted to in an effort to attain structurally stable joints.

From 1921 to 1938, 25 patients had 28 operations at the New York Orthopedic Hospital for the relief of hip subluxation or dislocation following infantile paralysis. The procedures included 17 shelf stabilizations, 3 open reductions, 1 fascia lata transplant, 1 Hey-Groves procedure, and 6 fusions. One patient had a bilateral shelf operation, 1 a fusion following an unsuccessful shelf, and 1 a Hey-Groves stabilization subsequent to a failure by fascia lata transplant. The following is an end-result study of these cases.

### THE SHELF STABILIZATIONS

There were 17 shelf stabilization operations and these were performed on 16 patients. The age at operation varied from 6 to 28 years and averaged 14. All patients had structural instability and demonstrated telescoping on examination. Eight hips were subluxated and 9 were dislocated. Six patients complained of pain and 1 of fatigue only.

Varying degrees of weakness were found before operation in several or all of the muscle groups, but it was chiefly in the abductors and medial and lateral rotators that the greater degrees of involvement were most frequently found.

Mobility before operation was expressed in degrees in only 6 cases and averaged for flex-

ion, 100 degrees, extension, 11 degrees, abduction, 30 degrees, adduction, 41 degrees, medial rotation, 22 degrees, and lateral rotation, 44 degrees. The average index of motion<sup>1</sup> was 70 (normal 90 to 110). Most of whatever limitation of motion was present occurred in the arcs of abduction and medial rotation. Conversely, there was some increase in mobility in adduction and lateral rotation.

All the patients limped badly not only on account of the structural instability under consideration but also because of the widespread and severe paralysis that was generally present. Braces and crutches were often required and frequently stabilizing and reconstructive operations were necessary on other joints.

Preoperative x-ray studies, besides demonstrating a subluxation or dislocation, usually revealed an elongated, shallow acetabulum with an oblique roof.

In 13 of the 17 operations, the shelves were formed by turning downward a mass of bone from the ilium and buttressing it in place with bone fragments placed between the ilium and shelf. This was generally satisfactory but difficulty was sometimes experienced in getting the shelf to bend over low enough to lie closely over the head which usually had been pulled down as far as possible or had been reduced. In 4, the shelves were constructed by turning outward a mass of ilium and inserting fragments or a slab of bone within the gap just above the head. As in the former technique, shelves were sometimes formed too high. It is our custom at present to drive a free graft from the ilium into a slot just above the head as this method better provides for accurate placement.

In 3 of the cases only that portion of the ilium was used that comprises the roof of the acetabulum. In 1 of these the mass of bone was turned downward thereby correcting the obliquity of the roof and in 2 it was turned outward and the gap was filled with bone fragments. Good results were obtained in the two but only a fair one in the first.

Reduction was accomplished in 6. Only traction and abduction were required in 2 but in the others, open reduction was necessary in which all obstacles to replacement were divided or removed and the upper acetabulum deepened with a gouge in one.

Postoperative x ray films revealed well placed shelves in 10 instances (62.5 per cent of 16—no postoperative film in 1) fairly good but placed a little too high in 3, and poor in 3 because of too high a position for function.

There were no operative deaths. One patient died 1 year after operation of a kidney condition.

Plaster immobilization was maintained for an average of 8 weeks and the patients were allowed up at an average of 10 weeks.

Two patients subsequently had osteotomies for the correction of anteversion.

### RESULTS

All the patients were examined 1 to 19 years after operation. The average time was 7½ years. The results are classified under the following headings:

**Stability—clinical** Upward telescoping from a position of rest was absent or practically so in 14, or 83 per cent, of the cases. This is the clinical test for structural stability. Nine of the patients stated that their hips felt stronger than before operation and 2 noticed no difference. This question could not be determined in 6.

**Stability—roentgenographic** Follow up x ray films were taken of all the hips with patients either in the standing position or at rest. Sometimes comparative films in the two positions were also obtained in order to demonstrate any amount of telescoping. Good shelves offering adequate support were revealed in 7 cases, 41 per cent, fairly good in 2, fair providing only partial support in 3 and poor in 5 because of total lack of function.

In 2 of these the shelves had been placed too high in 1 the resultant shelf was very small and so obliquely situated as to offer little if any support. In another the shelf underwent subtotal absorption and in the last dislocation above or behind the shelf occurred when the hip was stretched in an attempt to correct excessive abduction. Reduction by manipulation was unsuccessful and an intertrochanteric fracture was sustained. This hip was later fused.

Absorption of the shelf could not be accurately determined because postoperative and end result roentgenograms in comparative positions were not always available but there appears to be definite evidence that subtotal absorption occurred in 1 partial in 1 and slight in 3.

**Pain** Six patients complained of pain before operation and all but one were relieved. On the other hand, one individual who was without pain before had pain afterward. This was the case which redischarged following stretching and then sustained a fracture on attempted reduction. One other patient has pain after walking one mile.

**Motion** Mobility was not affected by the procedure. The average index before operation was 70 and afterward 73.

**Abductor power** The power of abduction was the one muscle factor which was thought might be considerably affected by the operation. Although the preoperative and follow up muscle tests were usually performed by different individuals, it was nevertheless felt that a comparative study of the abductor strength before and after would be of interest. The results are as follows:

There was no change after operation in 1—power was poor before and poor after. In 8 there was less power after operation. Of these there was a trace before and none after in 1; in 4 it was poor before and none after; in 2 it was fair before and none after; and in 1 it was fair before and poor after. In 5 there was more power after operation: poor before and fair after in each.

**Limp** This factor was difficult to evaluate as so much of the limp was produced by the muscle paralysis. All the patients limped before and all limped afterward, 10 severely.

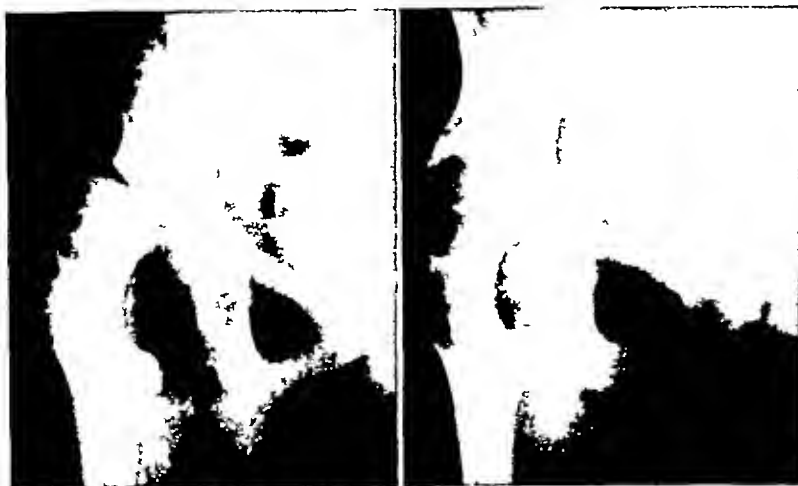


Fig 1 Stabilization by a shelf turned downward a, left, Before operation, b, 9 years after operation The patient has no pain but feels the hip slip now and then Slight upward telescoping and severe abductor lurch on examination



Fig 2 Stabilization by a shelf turned outward a, left, Before operation, b, 13 years after operation The patient has no pain and walks with a moderately severe abductor lurch No upward telescoping

5 moderately, and 2 without qualification By comparing preoperative and postoperative descriptions of gait that were available in 10, it was ascertained that 4 individuals limped less after operation and 6 the same

It seems established, therefore, that well formed, properly placed shelves will give structural stability to most of these hips and

will usually relieve pain but will not greatly improve the limp because of the extensive muscle paralysis still extant Factors that render the procedure more difficult and which in some instances may be so marked as to contraindicate the operation, are complete paralysis of the medial rotators with a position of marked lateral rotation of the head and



Fig. 3. Stabilization by reduction and turning out of the acetabular roof. a, left, Before operation. b, 24 years after operation. Reduction as apparently into the false acetabulum. The patient has no pain and less of limp than before operation. No upward telescoping and moderate lurch on examination.

pronounced ligamentous relaxation of the joint with excessive lateral play of the femoral head which would then be likely to pass laterally from beneath the shelf on weight

bearing. A forwardly directed position of the head due to anteversion may be corrected by a supracondylar osteotomy but in such an instance there should be enough power in the



Fig. 4. Illustration of only partial support by shelf that is placed too high. a, left, Before operation. b, after and c, right, and 4 years after operation. The patient

states that she now has stability and has been relieved of pain. No upward telescoping and marked limp on examination.



Fig 5 Failure of stabilization because of too high a position of the shelf a, left, Before operation, b, center, and c, right, 4 months and 8 years after operation The

patient has no pain and says that the hip feels stronger and does not slip as before operation Examination reveals upward telescoping and a severe lurch

medial rotators to maintain the leg in a neutral position of rotation

#### STABILIZATION BY OPEN REDUCTION

Three patients, 2 with dislocations and 1 with a subluxation, had only open reductions Their ages were 8, 12, and 14 years Abductor power was either absent or poor, and the medial rotators were either fair or zero The acetabular cavities were shallow but with a fairly good roof in 2 Anteversion of the femoral neck was extreme in 2 and in 1 a coxa valga was present as well

At operation, the acetabula were deepened sufficiently to socket the heads firmly This procedure required the removal of bone as well as cartilage in 2 and probably also in the third patient

The reductions were maintained in all but at the expense of mobility When the patients were examined 3, 10, and 14 years after operation, fibrous ankylosis, limited mobility with an index of only 31, and bony fusion were respectively found

In the case of the patient in whom a limited range of mobility was preserved, an osteotomy for 90 degrees of anteversion was performed 2 months after reduction had been carried out

#### STABILIZATION BY FASCIA LATA TRANSPLANT

A boy of 4 whose reducible dislocation was stable in medial rotation was treated by a fascia lata transplant placed through drill holes in the anterior portion of the iliac crest and the subtrochanteric region of the femur to maintain the leg in this desired position This was not successful and 4 years later he was readmitted for a Hey-Groves stabilization

#### STABILIZATION BY THE HEY-GROVES TECHNIQUE<sup>1</sup>

At operation, it was found that the head could be easily reduced and was stable in more than 20 degrees of abduction, but that there was so much lateral movement that a shelf stabilization would have been extremely difficult The Hey-Groves technique was then performed after gouging the upper portion of the acetabulum to bone to correct its shallowness and obliquity

The postoperative roentgenogram showed a good reduction Plaster immobilization was maintained for 6 weeks At 11 months after operation, x-ray films revealed one-half of the head outside of the acetabulum on traction

<sup>1</sup>HEY GROVES ERNEST W Treatment of Congenital Dislocation of the Hip Joint with Special Reference to Open Operative Reduction The Robert Jones Birthday Volume London Oxford University Press 1928





Fig. 6. Stabilization by fusion. a, left. Before operation. b, 6 months after operation. When examined 6 years after operation, patient had no pain and lifted his moderate limp. He is about master and can walk 4 miles without trouble.



Fig. 7. Stabilization by fusion. a, left. Before operation. b, 3 years after operation. This patient, who is the one with only trace of quadriceps power, now has only moderate limp and has stable knee. The foot and ankle have been stabilized by triple arthrodesis and ankle fusion.

and three-quarters subluxated on weight bearing. At follow up examination 8 years later standing x ray films showed the head to be under the oblique roof of an elongated

acetabulum. The patient had a severe limp because of extensive paralysis. He had no pain and with a cane could walk a mile before noting hip fatigue.

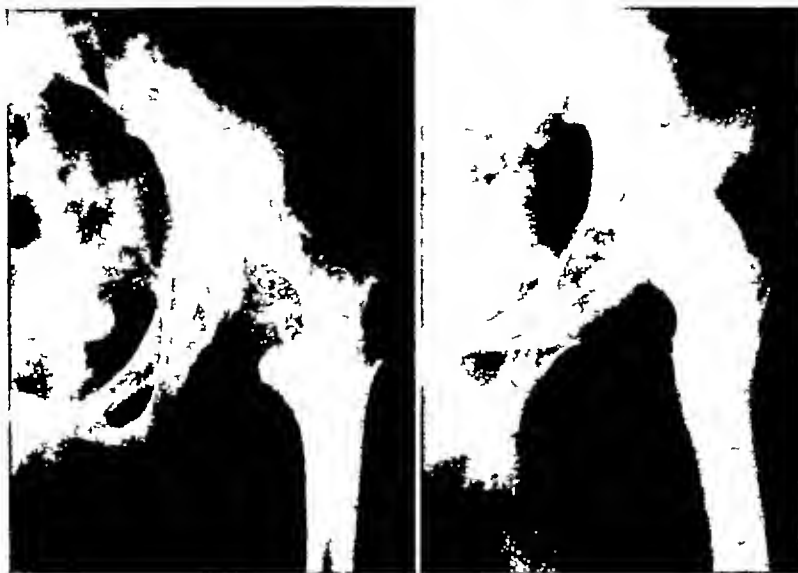


Fig 8 Stabilization by fusion a, left, Before operation, b, 6 years after operation This is the patient who before operation walked with extreme difficulty, using both hands on a cane because of instability and painful slipping of the joint. Now he has only a mild limp and has thrown away his stick

#### STABILIZATION BY ARTHRODESIS

Six patients had hip fusions Three were subluxated and three were dislocated One had failed to obtain a satisfactory result following open reduction and a shelf with subsequent complications Four complained of pain and 2 of fatigue and weakness All limps were severe and muscle paralysis about the joint was generally marked The greatest disability was in the case of a young man of 20 who supported himself with both hands on a cane and walked with great difficulty because of marked instability of the hip and painful slipping of the joint

The age of these patients varied from 15 to 31 years and averaged 20

In most of the cases, reconstructive or stabilizing surgery had been performed on the feet or knees before hip fusion, but in one triple arthrodesis of the foot and ankle fusion were done at a later date

The methods of fusion varied In 3, the acetabulum and femoral head were denuded of cartilage and a trochanteric mass of bone was driven along the neck into the ilium One of these failed and has apparently been suc-

cessfully re-fused with a Smith-Petersen nail driven into the ilium for immobilization followed 4 weeks later by implantation of bone chips In one case, the denuded head was placed in the similarly treated acetabulum without the employment of chips or a graft In another, bone contact was effected between the head, and false acetabulum and iliac grafts were turned down over the denuded head and neck Fusion resulted in both of these

In the case that had failed after previous shelf stabilization and was complicated by

TABLE I—LIMPS BEFORE AND AFTER HIP FUSIONS

Case	Before			After		
	Slight	Moderate	Severe	Slight	Moderate	Severe
1			+	+		
2			+		+	
3			+	+		
4			+		+	
5			+		+	
6			+			+

redislocation and fracture the head and neck were found at operation to have been largely absorbed. The end of the femur was therefore placed in the acetabulum and a trochanteric graft was placed across the joint. Fusion did not occur and reoperation with multiple bone chips was successful 4 years later.

These 6 patients have been examined from 1½ years to 12 years after operation. They are all fused clinically and roentgenographically and are free of pain except for the one who was re-fused by Smith-Petersen nail and chips and who was last seen only 7 months after the second operation. It is possible that her fusion is not yet solid but the last x-ray film indicated that it was.

Except for this one painful case in which the patient uses crutches and walks with great difficulty because of extensive paralysis and in whom fusion was considered necessary because of uncontrollable pain before operation, all have been considerably improved in regard to their limp, 2 of them markedly so (Table I). One has lost her severe abductor lurch and now walks with only a slightly perceptible limp and the other who previously walked with both hands on a cane now has only a mild limp and has thrown away his stick. Another who now has only a moderate limp is a scout master and walks 14 miles without pain or fatigue.

Although small in number these fusions have been highly satisfactory because they have not only relieved pain and produced stable hips but have also improved limps far more than the shelf stabilizations which in no

way could make up for that portion of the instability due to the muscle paralysis.

Fairly good ligamentous stability at the knee is a prerequisite for fusion in these cases, as the elimination of motion at the hip imposes increased strain on the knee which usually does not possess normal muscle strength.

Quadriceps power, although present in 5 of these 6 patients in the degrees of good or fair, does not seem to be an absolute necessity in one case that was fused with only a trace of power continues 5 years later to have a stable knee that does not give away. It is obvious, however, that in such a situation the ankle and foot must be stable or made so by triple arthrodesis and ankle fusion in 10 or 15 degrees of equinus.

#### CONCLUSIONS

1. Well constructed and properly placed shelves will provide definite structural stability but will not greatly improve limp because they do not eliminate or make up for the instability due to the muscle paralysis.

2. Hip fusion provides complete stability and effects considerable improvement in gait because the loss of muscle power is compensated for by elimination of motion.

3. Because arthrodesis of the hip imposes more strain on the knee, fairly good ligamentous integrity of the latter joint is a prerequisite.

4. From the experience with the one patient who had only a trace of power, paralysis of the quadriceps does not appear to be a contraindication to hip fusion for this condition.

## TWO-NEEDLE OXYGEN MYELOGRAPHY

### A New Technique for Visualization of the Spinal Subarachnoid Space

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IN the past few years much interest has developed in methods suitable for use in contrast visualization of the spinal canal by x-ray. This has been due in a large part to the frequency with which rupture of the intervertebral disc with extrusion of the nucleus pulposus occurs as a cause of sciatic pain.

We became interested in this problem after experience had convinced us that present methods of visualizing the spinal subarachnoid space were unsatisfactory. We found these to be inadequate from the standpoint of harm to the patient, difficulty in adequate visualization of the spinal canal, and inaccurate interpretation of the roentgenologic findings.

Lipiodol, thorium dioxide, air, and oxygen have all been employed for this purpose and each has its advantages and disadvantages. Lipiodol, when introduced into the spinal canal, serves as an excellent contrast medium but if not removed following the x-ray study may serve as an irritant to the arachnoid. Furthermore, its presence can be used to justify continuing symptoms and prolongation of litigation in industrial and other accidental injuries (5) (Fig 1). Attempts have been made to do away with these objections by removing the lipiodol under the fluoroscope. This, of course, necessitates another procedure, which in itself is undesirable. Moreover, the needle used in withdrawing the lipiodol must needs be larger than is usually employed in spinal punctures because of the viscosity of the substance. There is further objection found in the difficulty of securing accurate x-ray interpretation. This is because of false defects and false arrests in the flow of the substance when the patient is tilted.

Recently thorium dioxide has been employed. Unquestionably it gives the most satisfactory visualization of the spinal subarachnoid space. It has considerable inherent danger, however, and must be completely removed within 24 hours of its injection. The method that must be used to remove it is cumbersome and tedious and necessitates the employment of a large amount of hypotonic saline solution given intravenously in order to increase the secretion of cerebrospinal fluid.

Dandy (3, 4) first suggested that air be injected into the spinal canal as a contrast medium. He utilized this procedure in 1925. Nothing further was done along this line until 1934, however, at which time Coggeshall and von Storch demonstrated the caudal area of the spinal canal in three normal individuals by using injected air. In the same year Von Wagenen demonstrated the level of three spinal cord tumors in accordance with the principle that air injected below a tumor which was causing a complete spinal block would rise to the lower level of the block at the time when the patient was placed in an upright position. Scott and Young (9, 10) in 1937 and 1938 injected air into the lumbar spinal canal and demonstrated defects in the dural sac that were caused by extruded nuclei. In 1939 Chamberlain and Young described a technique for spinal air injections in which a single needle was placed above the suspected lesion and the subarachnoid space distended by alternately injecting 5 cubic centimeters of air and withdrawing 5 cubic centimeters of spinal fluid until air returned from the needle when withdrawal of spinal fluid was attempted. The patient was placed in Trendelenburg position for this procedure. Three hundred cases were included in this series. Poppen reported 50 cases of ruptured intervertebral discs in which oxygen instead of air was used.

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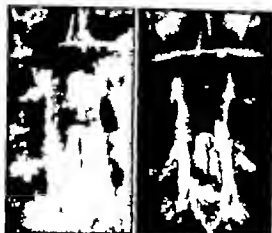


Fig. 1. Intraspinal lipiodol 9 months after injection. a, left, Before removal; b, after removal in the course of further investigation as to the cause of sciatic pain. Unexpected complete relief of all signs and symptoms following accidental removal.

in accordance with Chamberlain and Young's method. Both air and oxygen are readily absorbable and thus do not serve as permanent irritants. Their contrast qualities are satisfactory provided the canal is filled. However we found that in many cases the x-ray films made according to this technique were worthless from a diagnostic standpoint because of poor or inadequate filling. In our opinion this failure was both inevitable and unavoidable because of the fallacious hydrodynamics inherent in the technique. When everything is considered, however, it appears to us that the use of oxygen has the fewest disadvantages and that what disadvantages it does have lend themselves most easily to correction.

It seemed probable to us that the spinal subarachnoid space could be constantly completely and properly filled by oxygen if it was introduced in accordance with those hydrodynamic laws that govern the substitution of gas for liquid in a closed container. Furthermore, if this proved to be satisfactory as far as the method was concerned, we would then be dealing with a medium that was non-irritating, self-eliminating, inexpensive and universally available. Such a medium could be used repeatedly in the individual case. Its introduction could be so controlled as to permit the filling of all or any part of the spinal

Chart			
SPINOGRAM SHEET			
Name	Ward	Hospital No.	
Date			
Location of upper needle			
Location of lower needle			
Amount of oxygen injected (Approximate)			
Total protein of upper fluid			
Total protein of lower fluid			
<b>LUMBOSACRAL</b>			
	Average		
Lateral	Distance from iliac crest to crest		
	Basic kilovoltage		
		+8	
	Kilovoltage used		
A P	Time of exposure		
	A P diameter and level of crest		
	Basic kilovoltage		
		+8	
	Kilovoltage used		
	Time of exposure		
<b>DORSAL</b>			
	Average		
Lateral	Transverse diameter of chest at axillary level		
	Basic kilovoltage		
		+8	
	Kilovoltage used		
A P	Time of exposure		
	A P diameter of chest at axillary level		
	Basic kilovoltage		
		+8	
	Kilovoltage used		
	Time of exposure		
<b>CERVICAL</b>			
	Average		
Lateral	Transverse diameter of neck		
	Basic kilovoltage		
		+8	
	Kilovoltage used		
	Time of exposure		
Oblique	Right and Left Oblique diameter of neck		
	Basic kilovoltage		
		+8	
	Kilovoltage used		
	Time of exposure		
OPERATOR			
<b>INTERPRETATION OF SPINOGRAM</b>			
<b>CEREBROSPINAL FLUID DYNAMICS</b>			
Midlineal compression		Free Not free	
Jugular compression		Jugular release	
R 30		Fall	
Cell pressure	Manometer	Cell pressure	Manometer
		40	
		30	
30		20	
30			
40			
Interpretation	Total block	Partial block	Block and
(If total or partial block is present, record as above)	5 and		
Total protein of cerebrospinal fluid specimen			
DATE OPERATOR			



Fig 2 Normal filling of entire spinal subarachnoid space with oxygen injected according to the two needle myelogram technique a, Cervical—note the movement of the tracheal shadow laterally, b, thoracic, c, lumbar, d, sacral

subarachnoid space, and the errors attendant on fluoroscopy and those chemical changes in the cerebrospinal fluid that precluded later accuracy of diagnosis, could all be eliminated. Moreover, there would be no permanent visible foreign body left in the canal to serve as the starting point for neurosis and litigation on the part of the patient. We, therefore, modified Chamberlain and Young's method in such a way as to make it hydrodynamically correct and instead of one used two spinal needles. By placing one needle in the low lumbar region and varying the position of the other, we were able to fill the spinal canal accurately and satisfactorily not only in the lumbar region, but in the thoracic and cervical regions as well if we desired to do so. We employed oxygen instead of air, as there is no difference in their contrast qualities and oxygen is more readily absorbed.

The technique of two-needle myelography is as follows. On the evening before the procedure, the patient is given one ounce of castor oil by mouth, and a soap suds enema. This tends to remove the gas from the lower bowel, thus eliminating confusing x-ray shadows. Sometime during the following day he is taken to the x-ray room and is placed in the lateral position on a tilt-top x-ray table with a Bucky-Potter diaphragm. An adjustable web-

bing sling which is attached by its free ends to the table and which loops about his shoulders keeps the patient in place when the table is tilted. A low lumbar puncture is performed, followed by another puncture at the desired cephalad level of fill. If the entire canal is to be visualized, the cephalad needle is placed in the cisterna magna. If the thoracic and lumbar region is to be visualized, the cephalad needle is placed at the desired level in the thoracic region. If done with care and proper technique (6), the thoracic spinal puncture may be performed with impunity. If the lumbar area alone is to be visualized, the cephalad needle is placed between the twelfth thoracic and the first lumbar vertebrae. Number 18 gauge Fremont-Smith needles with three way stopcocks are used for the punctures. Simultaneous pressure readings, water manometers being used, are taken from the needles. The Queckenstedt block test is done, by means of a blood pressure cuff around the patient's neck to compress the jugular veins rather than by relying on digital pressure. The cuff pressure is increased by increments of 10 millimeters of mercury until a pressure of 40 millimeters is recorded in the cuff. The spinal fluid pressure is determined and recorded after each increment. The cuff pressure is then lowered by increments of 10 millimeters of mercury until



Fig. 3. Comparison of the visualizations of the spinal subarachnoid space by the needle oxygen myelographic technique. a, Anteroposterior views. b, Lateral views.

the pressure is zero in the cuff. The spinal fluid pressure after each increment is determined and recorded here also. By this method differential intraspinal pressures are obtained and if a block exists between the two needles, it may be demonstrated. Partial block may also be demonstrated by this method. In the latter there is a sluggish rise and fall in the caudal manometer associated with a free rise and fall in the cephalad manometer.

Two cubic centimeters of spinal fluid are now removed from each needle. This is for protein determinations and cell counts. Differential protein values are thus obtained simultaneously from below and above the suspected lesion. Care must be taken in evaluating the significance of these protein determinations however because in normal individuals the protein content of spinal fluid from the extreme caudal area may be a few points higher than that at a more cephalad level although both determinations show them to be within normal limits. Such a difference is of no diagnostic moment.

After the fluids are collected the patient's head is lowered to 25 degrees below horizontal and both needles are opened. Fluid will flow from the cephalad needle and, as this occurs, oxygen is slowly injected into the caudal needle. The injection is made from a sterile 50 cubic centimeter syringe which has been filled from a small oxygen tank. Care is taken

not to inject the oxygen under pressure as this expands the canal and may possibly distort it. In fact the patient will complain bitterly of radiating pain if the oxygen is introduced under pressure. When spinal fluid ceases to flow from the cephalad needle and oxygen appears both needles are closed. Stereoscopic lateral roentgenograms are now taken of the lumbar and thoracic levels. Oblique views are used and satisfactorily replace both the lateral and anteroposterior views in the cervical level, however. This is done so that the tracheal shadow will not be superimposed upon the injected column of air. As little delay as possible should occur between the time the injection is completed and the x-ray films are exposed because the gas tends to absorb quite rapidly. In some cases it is to avoid this complication that the needles are left in place while the lateral views are taken. After these are completed both needles are again opened and more oxygen is injected. The needles are then withdrawn the patient is quickly turned on his back and stereoscopic anteroposterior and oblique films are taken. We have found that 20 to 30 cubic centimeters of oxygen is sufficient to fill the lumbar area, 40 to 50 the midthoracic and lumbar areas and 75 to 100 the entire spinal canal (Fig. 2 a, b, c).

The technique with which the roentgenograms are taken is of great importance. If the necessary steps are not meticulously followed

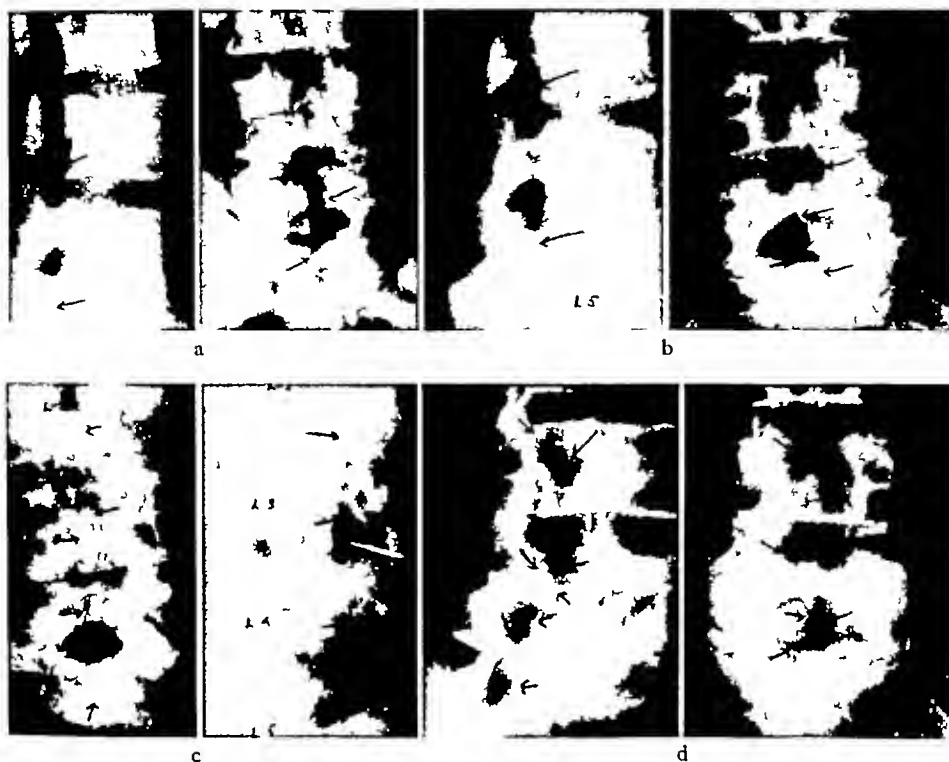


Fig 4 Visualization by two needle oxygen myelography of protruded nuclei in different sites in the low lumbar region a, Lateral, b, lateral, c, midline, d, lateral and midline

poor visualization of the air-shadow will result. When finished, the films should be black and white and not gray. Gray films dull the outline of the column of air and prevent intelligent interpretation. We have found that the tube must be calibrated for setting, distance, and basic kilovoltage. The tube which has been used in taking our films has had a distance of 30 inches, the setting being 50 milliamperes for all exposures. The variable factor has been the kilovoltage. This varies in accordance with the thickness of the patient. It has been essential, therefore, to measure the patient for each set of exposures, refer this measurement to the calibration chart for the basic kilovoltage needed by the particular tube that is in use and then, because of the need for contrast films, to add 8 kilovolts to the basic figure in order to get the actual kilovoltage that is required. To insure this being done, we have devised a chart (Chart 1) on which all these figures are recorded as they

are obtained, as well as other pertinent data such as the results of the Queckenstedt test, the total protein in the various specimens of fluid, and so forth. We are convinced that this tabulation has been a major factor in the production of satisfactory readable myelograms.

In the 11 months to January 1, 1942, 69 myelograms have been done by the two-needle method, on 60 patients. In 45 both needles have been below the twelfth thoracic vertebra, in 13 one needle has been in the cisterna magna, and the other in the lumbar region, and in 11 one needle has been inserted through one of the upper thoracic and the other through one of the lumbar interspaces. Even at their worst—and usually this was because of inadequate x-ray technique—the visualization of the spinal subarachnoid space by the two needle method was better than the average result obtained by the one needle technique and at their best exceeded those of the latter that had been considered perfect (Fig 3,a,b).





Fig. 5. Two needle oxygen myelogram of congenital absence of sacrum. Note termination of the subarachnoid space opposite the fourth lumbar vertebra. Verified by operation. a, left, Anteroposterior view b, lateral view

The greatest use of this two needle method was found to lie in the freedom with which it could be employed as a diagnostic aid in all varieties of problems affecting the spinal cord. This is best evidenced by the fact that it was an important factor in reaching the decision that 37 of the 60 patients studied did not need surgical interference. Forty observations were made on this group. Four were considered unsatisfactory and in 5 the findings were positive. These latter patients will be discussed. In the 31 remaining the findings were considered normal. None of these findings were confirmed by either operation or autopsy. Thus, in 50 per cent of the cases examined (31 of 60) the test demonstrated that there was no alteration in the shape of the spinal subarachnoid space (Fig. 2). This was a higher percentage of use as a means of investigation than would have been considered justifiable with any other medium. With lipiodol or thorotrast the surgeon would have assumed that the myelogram would have been negative rather than use these media in the absence of definite indications. With the oxygen myelograms it was possible to give the patient

factual assurance in regard to their spinal pathology, the only limitations in their use being those governing the performance of a spinal puncture.

Our experience is not yet large enough to do more than tentatively testify as to the accuracy of our method whether from the positive or from the negative viewpoint. Our evidence on this point follows. There were 9 patients on whom a diagnosis of protrusion of the nucleus pulposus following rupture of an intervertebral disc was made on the evidence of the myelogram and other data. The protruded nucleus was found at operation exactly as visualized by the myelogram in every case (Fig. 4a,b,c,d). Two needle myelographic visualization of the spinal subarachnoid space in one case of congenital absence of the sacrum (Fig. 5a,b), one case of congenital duplication of the lumbosacral spine (Fig. 6a,b) and one case of traumatic distorting adhesions and scar formation between the dura and the cervical cord were each confirmed in all details by the laminectomies. Seven patients were explored as ruptured intervertebral disc suspects in spite of negative two needle myelo-

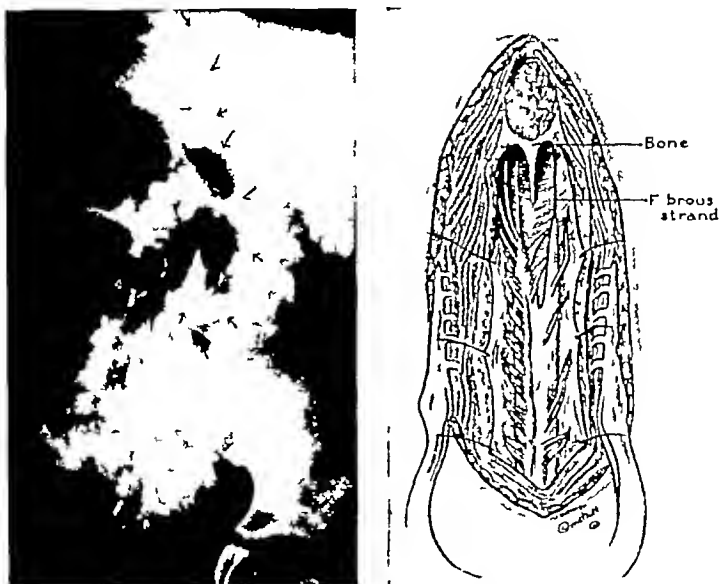


Fig 6 Two needle oxygen myelogram of congenital duplication of the lumbar spine and sacrum. Note the 2 separate subarachnoid spaces in the lumbosacral region a, left, Anteroposterior view, b, drawing made at operation

grams. No pathology was found in any instance. The operative findings disagreed with the myelogram in only 2 of the 23 patients that were operated upon. One was a patient with a metastatic tumor of the sixth dorsal vertebra and a dynamic block with myelographic evidence of involvement of the spinal meninges at the same level. Although a block was demonstrated at operation, no certain evidence of the meningeal involvement was found. In the other patient, the myelogram was interpreted as positive for an extruded nucleus by one and negative by another surgeon. An exploration without visualization of the intervertebral foramen demonstrated a thin layer of unidentifiable abnormally placed tissue on the anterior aspect of the low lumbar dura and no other pathological lesion. In one patient a protruded nucleus was diagnosed and removed at operation without any previous visualization of the subarachnoid space. Thus, of 23 patients, the two needle myelogram has accurately visualized the spinal subarachnoid space in 20, been useful but not accurate in 2, and not used in 1. All findings were confirmed by operation.

As noted above, 5 patients were not operated upon partly at least on account of the myelogram findings. All the findings were positive. In one the symptoms and other signs pointed to a tumor of the cervical cord. The myelogram, however, demonstrated a tumor which had invaded the upper thoracic subarachnoid space. Further investigation demonstrated that the symptoms were caused by a Pancoast tumor with a metastasis (Fig 7). Another patient had a sacral spina bifida with chronic ulcers of the feet. The myelo-



Fig 7 Pancoast tumor of right lung. a, Normal two needle cervical oxygen myelogram, b, two needle thoracic oxygen myelogram showing (arrow) tumor projecting from the anterior bony wall of the spinal canal, c, x-ray film of chest showing shadow of tumor in apex of right lung. Patient's symptoms were all in his right arm.

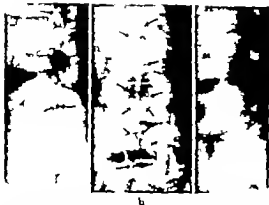


Fig. 8. Two-needle oxygen myelogram showing partial closure of spinal subarachnoid space opposite the fourth lumbar vertebra because of adhered arachnoiditis following compression fracture of the body of the fifth lumbar vertebra. a, Lateral view; b and c, anteroposterior and lateral view 1 week later.

gram demonstrated a deformity in the lumbosacral subarachnoid space. She is awaiting exploration. Two other patients had spinal cord and cauda equina injuries, respectively. Myelograms demonstrated arachnoidal adhesions and deformity of the thoracic cord in the one and arachnoidal adhesions with closure of the lower lumbar sac and distortion of the roots of the cauda equina in the other (Fig. 8). The first refused and the second recovered without operation. The fifth case was shown to have the typical deformity caused by a protruded nucleus pulposus. He refused to be operated upon and left against advice.

Myelograms were repeated in 5 instances because the first visualizations were not satisfactory. Satisfactory visualization of the subarachnoid space was eventually obtained in every case. In 4 other instances the original unsatisfactory myelograms were not repeated for various reasons and a diagnosis was reached without the assistance of this procedure.

#### SUMMARY

The advantages and disadvantages of lipiodol, thorium dioxide, air, and oxygen as media for the visualization of the spinal subarachnoid space are discussed, and attention

is called to the difficulties caused by the hydrodynamic laws governing the substitution of a gas for a liquid when this substitution is attempted in a container that has only one opening. We consider this to be a fault inherent in the technique advocated by Chamberlain and Young in their use of air or oxygen. The superiority of oxygen over other media advocated for this purpose is asserted because it is nonirritating, self-eliminating, inexpensive and universally available, and because it cannot be made to serve later as an excuse for the prolongation of symptoms or the initiation of litigation on the part of the patient. By using a two-needle technique for its introduction, we have demonstrated that its distribution can be so controlled as to permit the filling of all or any part of the spinal subarachnoid space and that it can be used repeatedly in the individual case without jeopardizing the accuracy of later studies of the chemical constituents of the cerebrospinal fluid.

#### CONCLUSIONS

A method for the use of oxygen as a contrast medium in the visualization of the spinal subarachnoid space is described.

The method employs 2 needles and can be used to fill any or all of this space without distortion in accordance with the recognized laws governing hydrodynamics, and as often as may be desirable or necessary in the individual case without affecting later observations.

Evidence as to its general usefulness and accuracy as a diagnostic aid is presented.

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# THE TREATMENT OF PILONIDAL SINUS

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**A**N interesting fact brought out by the present war is the high incidence of pilonidal sinus in young adult males. The Army has insisted that this simple congenital anomaly be corrected before a candidate is acceptable for military service. As a result, every military hospital has more of these troublesome lesions on the wards at one time than the average surgeon sees in many months of active civilian practice. Although never threatening life, this condition presents a serious problem because of incapacitation for normal activity. Since the aim in military medicine must be to keep a maximum number of men fit for active duty, the proper treatment of this distressing lesion becomes even more significant than in peace time practice.

There has been no widely adopted well standardized procedure for the treatment of pilonidal sinus. The reported results by all methods used until very recent years have been largely unsatisfactory. General practitioners treating an occasional patient have had discouraging results. The incidence of delayed wound healing and the recurrence rate have been high. Some surgeons have advocated primary closure, some partial closure with drainage, and others equally vigorously have recommended excision, with or without cautery, followed by open packing and healing by secondary intention.

Because of its apparently trivial character, the excision of a pilonidal sinus has not been viewed with any particular concern. Consequently, in the various operative procedures used, there has been little careful attention to technical detail. Yet, irrespective of the treatment used, there are probably few operations in surgery in which the most meticulous attention to detail brings such gratifying results. This fact is proved by the excellent results reported for primary closure by Stone and by

Ferguson and McCray and for cautery excision with secondary closure by Rogers and his associates (9, 10).

The incidence, embryology, pathology, and clinical features of this lesion have been described frequently and are adequately presented in the papers of Gage (6, 7), Fox, Stone, Breidenback, Burgess, Rogers (9, 10), Ferguson, and others. This paper is confined to the treatment of pilonidal sinus. The results from the Peter Bent Brigham Hospital are given, and standard procedures for primary closure and cautery excision are outlined.

It is sufficient here to state that pilonidal cysts and sinuses are congenital lesions which become of surgical significance due to the high frequency of infection. Two theories have been proposed concerning their origin. Fox believes they result from invagination of ectodermal derivatives in the sacrococcygeal area. Gage (6, 7) is of the opinion they are due to persistent remnants of the neurenteric canal. In any case, these epithelial sacs commonly present one to several openings in the midline over the lower portion of the sacrum. The various series of studies in the literature report this anomaly 3 to 4 times as frequently in males as in females (8, 10). It is most commonly recognized in the third decade of life. In the last 45 cases examined at the Peter Bent Brigham Hospital, 34 were between 20 and 30 years of age. This places the highest incidence directly in the military group.

The presence of a pilonidal sinus is usually unknown until secondary infection occurs. Repeated minor trauma and chronic irritation are undoubtedly significant in the precipitation of this infection. Any or all of the signs of acute inflammation may be found, intermittent discharge from the sinus openings is characteristic, and the formation of secondary fistulous openings is common. Abscesses develop which rupture spontaneously or require surgical drainage.

From the Surgical Clinic of the Peter Bent Brigham Hospital

## TREATMENT

In the presence of an acute inflammatory process the treatment should be clear. Heat and immobilization together with incision and drainage of localized suppuration are universally recommended and practiced. After the acute infection has been controlled the lesion should then be eradicated surgically to prevent almost certain recurrence of difficulty.

Each case must be considered individually. We have employed 2 types of surgical therapy. Excision followed by closure of the wound with fine silk is the procedure of choice and will be described in detail. Caution, excision with open packing and secondary healing is the preferable treatment in a certain percentage of cases and will be briefly outlined. We feel certain that the surgeon should be familiar with both techniques and the indications for each because no single procedure can best be universally adopted.

## EXCISION WITH PRIMARY CLOSURE

The majority of patients can be treated by excision and primary closure. This is most satisfactory to the patient since in a short period of time the entire treatment is completed, repeated dressings are unnecessary and early normal activity may be resumed comfortably. For this to be possible, however treatment must be instituted early, that is before repeated bouts of infection have resulted in widely dissecting secondary sinus tracts which would prevent approximation of the wound edges without tension. It can be instituted safely only in the absence of acute inflammation. Also the patient must be willing and able to undergo a short period of hospitalization.

**Anesthesia.** Local anesthesia is not recommended for this operation because infiltration in the neighborhood of the dissection may obscure the necessary accurate delimitation of sinus tract from normal tissue. We use spinal anesthesia as a rule since this is admirably suited to young otherwise healthy adults. Inhalation or intravenous anesthesia may be used.

**Technique.** The patient lies face down on the operating table with the head turned to one side. The table is broken so as to lower

both the head and feet as shown in Figure 1 A. Two 3 inch strips of adhesive tape are applied to the buttocks opposite the lower margin of the sinus and the buttocks are separated by attaching these to the sides of the operating table as shown in Figure 1 A and B. The field is then prepared and suitable drapes applied.

The skin incision is outlined (Fig. 2) from 0.3 to 0.8 centimeter to each side of the midline dimple or sinus tract openings. It should extend a sufficient distance above and below the sinus tract to insure complete removal and also to facilitate closure of the wound without tension.

The operator and his assistant place fingers evenly along the gauze covered margins of the incision and apply firm steady pressure as illustrated in Figure 3 A. In this manner the dissection proceeds in a bloodless field. With exact hemostasis and careful inspection of the tissues, the incision on both sides of the tract is carried down to the sacrococcygeal fascia. With very little experience it is easy to distinguish normal subcutaneous tissue from sinus tract under direct vision provided accurate hemostasis is maintained.

We do not recommend the injection of methylene blue or other dyes into the sinus tract before operation. As Rogers (10) has pointed out, there may be danger of extravasation of the dye into normal tissue leading to an unnecessarily wide extirpation of normal fat. The line of demarcation must be planned so as to remove the narrowest possible margin of normal tissue for the wider the excision the greater the amount of undercutting that is necessary and the less the possibility of bringing the skin margins together without tension.

The ellipse of tissue containing the sinus tract is freed from the sacrococcygeal fascia at the upper margin of the wound grasped with suitable forceps (Fig. 3B) and peeled downward. Again, this dissection is carried out under careful direct vision with meticulous hemostasis. All bleeding points are secured with fine silk. Throughout this procedure the sinus tract itself should never be actually visualized. If the dissection comes too close to the dull grayish tissue which characteristically surrounds the tract, then the operator must go back and excise a slightly wider margin of fat.

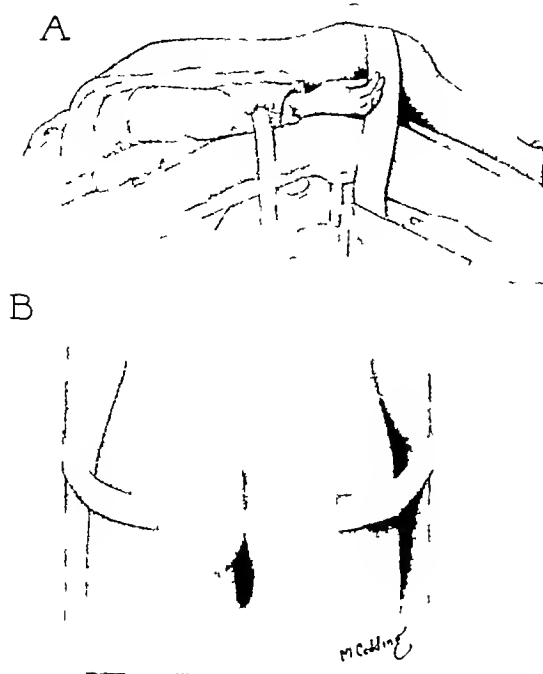


Fig 1

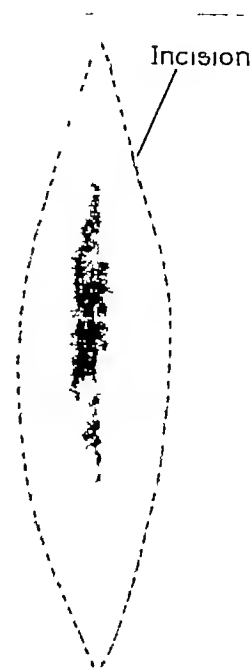


Fig 2

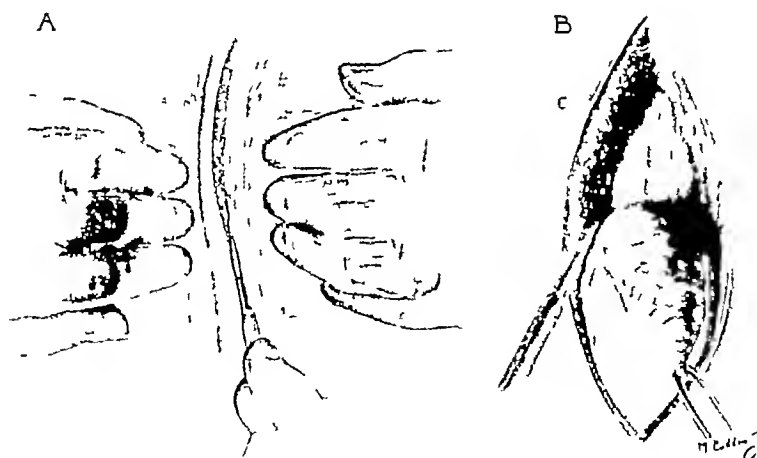


Fig 3

Fig 1 A, Position of patient on the operating table B, Separation of the buttocks by adhesive straps attached to the sides of the operating table

Fig 2 Outline of skin incision

Fig 3 A, Bleeding controlled by finger tip pressure at wound margins exerted by operator and assistant B, Reflection of sinus tract and margin of normal fat from the sacrococcygeal fascia

If the sinus tract is inadvertently cut across and there is gross leakage of its contents into the wound, then primary closure should be abandoned

At this point in the operation the specimen is carefully examined by the pathologist or someone not in the operating team to make sure that the entire tract has been excised and

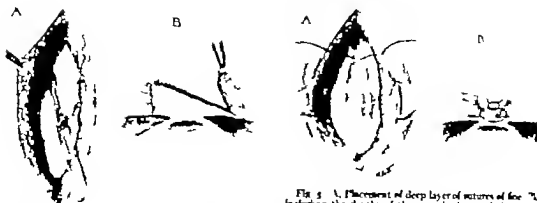


Fig. 4. A and B Mobilization of wound edges by under cutting.

that it has not been broken into. When this is certain the wound edges are undermined for a short distance in all directions by separating the overlying tissues from the sacrococcygeal fascia as shown in Figure 4. A and B. Bleeding again is controlled with fine silk ties. Hemostasis by temporary packing of the wound alone is dangerous in these cases because subsequent oozing with hematoma formation makes the success of primary closure much less probable.

Closure is begun by placing a row of interrupted sutures of fine silk as shown in Figure 5A. Each suture takes equal bites of the subcutaneous tissue on either side of the wound and also includes a bite of the sacrococcygeal fascia in the midline. It is only in this way that dead space in the floor of the wound can be eliminated. When this row of sutures is placed the adhesive straps separating the

Fig. 5. A, Placement of deep layer of sutures of fine silk including the depths of the wound edges and the sacrococcygeal fascia in the midline. B, Elimination of dead space by tying deep layer of sutures after adhesive strapping has been released.

buttocks are released and the sutures are tied as illustrated in Figure 5B. These sutures are carefully spaced with a view to use a minimum amount of suture material.

The importance of an accurate skin closure cannot be overemphasized. For this reason we recommend the use of vertical mattress sutures of fine silk which insure exact approximation of the skin margins and at the same time build up the subcutaneous tissues (Fig. 6). If some tension is present 1 or 2 retention sutures of fine stainless steel wire or silk worm gut may be used, but this should rarely be necessary.

**Dressing.** A small firm pressure dressing is applied directly over the wound and the undermined area. A rubber or sea-sponge may be used here to good advantage. Broad strips of adhesive tape are then used to strap the buttocks together and hold the dressing snug against the wound.

**Postoperative care.** The patient is kept lying either flat on his back or on his abdomen and is discouraged from lying on his side during the first week. Diet is limited first to fluids and then to low residue foods. Small doses of paregoric are administered daily for the first 5 to 7 days in order to prevent bowel movements. At the end of this time paregoric is discontinued, mineral oil is given by mouth and a small warm oil retention enema is administered with a soft rubber catheter.

The dressing is not examined until the 5th day unless there has been fecal soiling. If this

TABLE I—OPERATIVE TREATMENT OF PILONIDAL SINUS

PETER BENT BRIGHAM HOSPITAL, 1936-1940

Operation	No. of cases	Recurrence	% Recurrence
Simple excision			
Open packing	3		4.3
Excision			
partial closure	5		20
Primary closure with catgut or catgut and silk	6		33.3
Primary closure without catgut, with silk or silk worm gut or steel wire	13		
Total	67	6	8.9

has occurred a complete new pressure dressing is applied immediately. Skin sutures are removed on the 8th postoperative day and the buttocks are held in approximation by adhesive strapping until the 12th to 14th day. The wound should be examined and cleaned as necessary following every defecation during this period. Patients leave the hospital usually in 10 to 14 days.

#### CAUTERY EXCISION WITH SECONDARY CLOSURE

For those cases which are unsuitable for primary closure according to the method just described, we believe that cautery excision under local or spinal anesthesia with open packing of the wound and healing by secondary intention is the method of choice. The indications for this type of treatment are (1) large sinuses with widespread secondary fistulous tracts, (2) recent acute infection, (3) marked obesity, (4) gross contamination of the wound in attempted primary excision, and (5) inability of the patient to spend 10 to 14 days in the hospital.

Even endothermy excision should not be attempted in the presence of acute suppuration. Incision and drainage followed by usually at least 3 weeks of heat, sterile dressings, and observation are indicated before planning excision.

The technique recommended for cautery excision is that first suggested by Stanton and modified by Rogers and his associates (9, 10). It is well described and illustrated by Rogers and Hall (10) and is only briefly outlined here.

While the buttocks are held apart under tension, the sinus is split in the midline with the actual cautery down to the sacrococcygeal fascia from about 1 centimeter above to 1 centimeter below the pathological tissue. Each half of the sinus tract is then excised with the cautery by undercutting the wound edges. A very narrow margin of skin is removed with the underlying fatty tissue to at least 0.5 centimeter lateral to the sinus. Bleeding is controlled with the cautery. This procedure allows the wound to fall widely apart and with good hemostasis the tissues are carefully examined in order to insure complete removal of the tract. The wound is packed

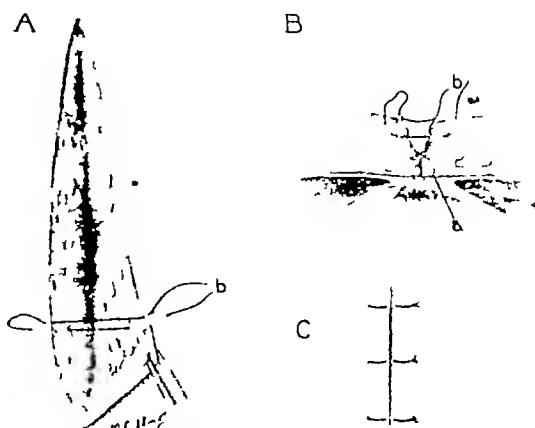


Fig. 6 A B C Skin closure with vertical mattress sutures of fine silk.

open loosely and the edges are protected with vaselined gauze. This operation may be carried out with the patient in the prone position as illustrated in the technique for primary closure (Fig. 1) or in the lateral position as recommended by Rogers and Hall (10).

The first dressing is not done for 3 to 5 days, but from this time on it is advantageous to do dressings frequently. We have found that the slough disappears and granulations become clean and healthy more quickly by changing the dressing every 2 days in patients who are not in the hospital and daily in hospital patients. A very satisfactory dressing consists in a gauze sponge soaked in an emulsion of equal parts of eusol (12.5 gm. of boric acid, 12.5 gm. of chlorinated lime made up to 1,000 c.c.) and mineral oil loosely packed into the open wounds. The skin margins are protected at each dressing by vaselined gauze. It may be that a sulfonamide administered locally or orally would be of assistance in the seriously infected cases.

TABLE II—RESULTS OF PRIMARY CLOSURE OF PILONIDAL SINUS (WITHOUT CATGUT SUTURES)

	PETER BENT BRIGHAM HOSPITAL, 1932-1940	
	Cases	Per cent
Number of cases	43	
Recurrences	3	6.9
Suppuration (healing time in this case—2 mos.)	1	2.3
Faulty healing due to separation of wound edges (Average healing time 3 to 4 wks.)	6	13.8
Discharge of sutures without wound infection or faulty healing	3	6.9



We agree with Rogers and Hall (10) wholeheartedly that it is largely the care with which dressings are carried out postoperatively that determines the comfort of the wound and the speed of healing. Premature bridging of epithelium over granulations must be prevented in the later stages of healing. Soft pliable nonpainful scars can be obtained in 6 to 12 weeks after this type of excision.

### RESULTS

In 1937 one of us (3) reported the results of treatment of pilonidal sinus from the Peter Bent Brigham Hospital in a paper emphasizing the importance of the suture material used. Between 1932 and 1936 63 patients were submitted to operation. Eighteen were packed open with a recurrence rate of 27.6 per cent. In 45 cases primary closure was attempted with a recurrence rate of 22.2 per cent. It was pointed out that the recurrence rate in the latter group was almost directly proportional to the amount of catgut used. Thus in 17 cases closed with heavy catgut there were 11 cases of secondary healing of the wound and 6 recurrences while in 10 cases closed with fine silk or silkworm gut only all the wounds healed *per primam* with 1 recurrence.

Since that report special attention has been directed toward the treatment of these lesions. It has become more and more apparent that no special procedure should be adopted as a routine treatment. Each case must be analyzed carefully and operative treatment carried out according to the particular indications. The results of treatment on this basis since the previous report have been gratifying. Table I shows the incidence of recurrence in 67 cases treated between July 1936 and March 1941. Eight other cases are not included because of inadequate follow-up data. These 8 cases all had good immediate results.

Of these 67 cases, 39 or 58 per cent were treated by primary closure. Since the choice of treatment was considered individually and since the results are satisfactory, we believe this represents a fair estimate of the proportion of cases suitable for primary closure.

Table II presents the results of all the patients from 1932 to 1940 treated by primary

closure in which no catgut was used. It demonstrates the very small percentage of complications in this method of treatment.

### CONCLUSIONS

1. Because of the high incidence of pilonidal sinus in young adult males in the military service improvement and standardization of surgical treatment are highly desirable.

2. There is no one routine treatment adaptable for all cases. About 60 per cent are suitable for excision with primary closure. The remainder can best be treated by cautery excision followed by open packing of the wound. The technique and indications for each procedure are presented.

3. When primary closure is adopted as the proper treatment the use of catgut is contraindicated. Fine silk is the suture material of choice.

4. Successful primary closure depends upon meticulous attention to detail: accurate hemostasis, careful dissection under direct vision, obliteration of dead space, exact approximation of skin margins, and a firm well applied pressure dressing.

5. Successful cautery excision and the speed and comfort of wound healing are largely determined by the care taken with the frequent postoperative dressings.

6. The incidence of recurrence in this clinic has been reduced from 22 per cent to 4.3 per cent for open excision with packing and from 27 per cent to 6.0 per cent for primary closure.

7. More important than the method of treatment selected is the precision with which it is carried out.

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# THE ANATOMY OF THE PELVIC AUTONOMIC NERVES IN RELATION TO GYNECOLOGY

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INVESTIGATORS of the gross anatomy of the hypogastric (presacral) and other autonomic pelvic nerve plexuses have left pelvic surgeons in an unsettled state relative to the surgical anatomy of this region. Clinicians' inability to identify the nerves during plexus resection operations has not served to clarify this subject.

In a series of studies concerned with the gross anatomy of the female pelvis our dissections have enabled us to recognize details of the structure of the pelvic soft parts which have long been the subject of considerable confusion (4, 5, 6). As a corollary to these studies we have naturally turned to a consideration of the distribution of the pelvic autonomic nerves. Four drawings were prepared from a series of dissections carried out upon particularly favorable specimens. The dissection depicted in the first illustration was made to correspond to the exposure employed in the operation for "presacral nerve" resection. The second and third illustrations, also vital in their surgical bearing, portray the details of the autonomic nerve plexuses in relation to other pelvic structures, including their mode of distribution to the pelvic viscera. The fourth dissection, by more complete exposure, reveals the conventional anatomy of the sacral plexus and its relationship to the sympathetic chain and to the origin of the parasympathetic nerves.

## PERTINENT LITERATURE

The lumbar and lower thoracic sympathetic ganglia, and the superior, middle, and inferior hypogastric plexuses constitute the

sensory pathways from the pelvic viscera.<sup>1</sup> A most important exception in gynecology is that the nerves from the ovaries, similar to their vascular supply, pass somewhat independently to the inferior mesenteric plexus, as do also the sensory fibers from the lower bowel and fallopian tubes.

*Anatomy.* If one starts with the region of the solar plexus, just beneath the diaphragm, there are the two semilunar ganglia and the celiac plexus. From this region sympathetic nerve plexuses communicate at a slightly lower level with the subordinate aorticorenal ganglion, the renal plexus, and the transverse aortic bar. All of these are really an integral part of the solar plexus, and here arise the two or three intermesenteric nerves which pass downward over the anterior surface of the aorta, receiving fibers from the inferior mesenteric ganglion and the lumbar sympathetic ganglia. Between the intermesenteric nerves are many intercommunicating fibers.

At the level of the bifurcation of the aorta the intermesenteric nerves join to form the superior hypogastric plexus, more commonly known as the "presacral nerve," which is the chief supply of the bladder, the rectum, and the internal genitalia except the ovary and part of the fallopian tube. The location and relations of the superior hypogastric plexus are important because its removal is frequently resorted to for relief of intractable pelvic pain. It is usually a moderately wide plexus formed from the two or three incompletely fused trunks of the intermesenteric nerves. In perhaps 20 per cent of the cases there is complete fusion, with resultant formation of a single nerve. The superior hypogastric plexus

<sup>1</sup>The preganglionic cells of the sympathetic pathways lie in the lowest thoracic and upper lumbar levels of the intermediate lateral column. These cells send their axons out over the lower white rami of the thoracolumbar outflow to the lumbar and preaortic ganglia. Postganglionic neurons originate in the sympathetic trunks as well as in the preaortic ganglia to form a plexus descending along the abdominal aorta (White 1935).

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spreads out behind the peritoneum in a bed of loosely meshed areolar tissue which lies upon the bodies of the 4th and 5th lumbar vertebrae. In the midline the middle sacral artery is situated between the nerves and the anterior surface of the vertebral bodies. There is a bilateral communication between the "presacral nerve" and the lumbar sympathetic ganglia by means of fine nerve strands which pass from the ganglia to the nerves located behind the common iliac arteries.

The superior hypogastric plexus may or may not form a middle hypogastric plexus. When present, the plexus is a flat expanse of neurofibrous tissue overlying the promontory and extending just below it this plexus divides to form the bilateral inferior hypogastric plexuses, or hypogastric nerves. Each consists of two or three interlacing nerves, forming a long narrow plexus. The fibers of the inferior hypogastric plexus pass downward and lateralward near the sacral end of the uterosacral ligament then forward over the lateral surface of the rectal ampulla to join the pelvic plexus, sometimes known as the uterovaginal plexus the cervical ganglion or the ganglion of Frankenhäuser of which the hypogastric plexus furnishes the main sympathetic supply. The additional nerve supply to the pelvic plexus consists of fine fibers from the sacral sympathetic chain and parasympathetic branches (erigens or pelvic nerve) usually arising from the 2d to the 4th anterior roots of the sacral nerves.

The pelvic plexus is described as a bilateral thin sheet of nerve fibers imbedded in connective tissue and spread out over an area of 2 by 3 centimeters upon the anterolateral aspect of the ampulla of the rectum. It is situated in the broad ligament at the level of the cervix, somewhat lateral to the lateral fornix of the

vagina, upon the posterior surface of Mackenrodt's ligament. All of the pelvic viscera are supplied almost exclusively by the pelvic plexus. The nerves to the uterus, bladder and vagina are said to leave the plexus anteriorly separate from the nerves to the rectum, the uterine nerves leaving the vesical nerves to pass along the uterosacral ligament to the cervix, medial to the crossing of the ureter by the uterine artery.

There are no large ganglia in the pelvic plexus. It consists of interlacing nerve fibers with numerous minute ganglia. Other minute ganglia the paracervical ganglia, which are offshoots from the pelvic plexus, are present in the paracervical broad ligament thaves behind the uterine artery a short distance from the uterus.

The uterus, as indicated, derives its nerve supply from the uterine portion of the pelvic plexus. There is said to be a small independent nerve supply direct from the hypogastric nerve. The nerves to the uterus follow the blood supply and some filaments may be traced grossly beneath the peritoneum into the uterine muscle. Microscopically nerve fibers may be found both between the smooth muscle fibers and around the capillary vessels. In the cervix the blood vessels are stated to be more scantily supplied with nerves. Beneath the columnar epithelium of the internal os are delicate parallel bundles of nerves, and under the epithelium of the vaginal portion of the cervix are nerve plexuses containing many spindle ganglion cells. Except for these there are almost no ganglia in the uterus.

The vagina is innervated by the vaginal portion of the uterovaginal plexus, with some fibers derived from sacral sympathetic trunk.

The ovary derives its nerve supply mainly from the ovarian plexus, a meshwork of nerve fiber bundles which arise from the aortic and renal plexuses and accompany the ovarian artery throughout its course. The high source of the ovarian nerve supply is as should be expected with realization that the ovary is embryologically an abdominal organ. The ovarian plexus invest both the ovarian artery and the vein. It supplies fibers to the broad ligament and to the fallopian tube as well as to the ovary and communicates in the broad

The parasympathetic postganglionic neurons cells lie in the lateral portion of the posterior horn of the sacral cord. Thence three nerves run out over the 2d, 3d, 4th and 5th sacral anterior roots and the sacral nerves, to emerge from the sacral foramina in the hollow of the sacrum. These run, the nerves proper, pass through the inferior hypogastric plexus. The distribution of these fibers was formerly supposed to be limited to the pelvis. Trueta, Mitchell and J. J. Bennett have traced a number of ascending strands which carry parasympathetic fibers via the inferior hypogastric plexus to the descending colon. Parasympathetic innervation of the uterus, bladder, ovaries, and testes has been demonstrated. Parasympathetic neurons constitute the autonomic plexuses in the muscular walls and mucosal spaces of the bladder and rectum as well as in the internal organs (H. H. H.).

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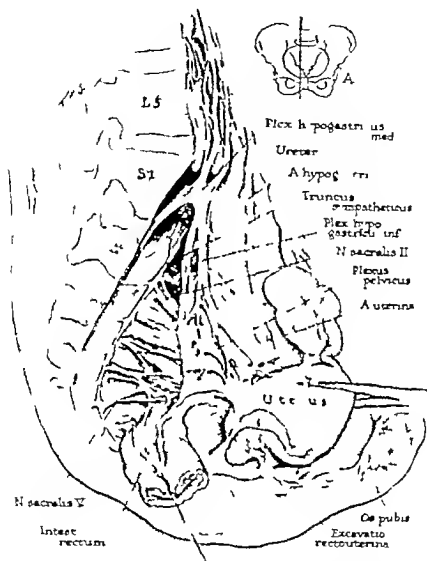


Fig. Presacral nerves, deeper dissection. Medial view of pelvis sectioned in paramedial plane through pubic tubercle of the right side (see inset). The terminal portions of uterine are intact; the fibrous lamina beneath the fatty preperitoneal layer has been freed and levated. A wedge-shaped piece of the fibrous lamina has been removed between the rectum and the autonomic plexus to expose the sacral plexus, parasympathetic nerves, sacral sympathetic chain, and subjacent pariformis muscle.

thetic, is exclusively excitatory or inhibitory they believe that the two co-operate with somatic nerves in regulating bladder function, but that the parasympathetics are more important.

Section of the superior hypogastric plexus does not greatly alter menstrual function and apparently does not interfere with delivery or disturb an motor function of the bladder.

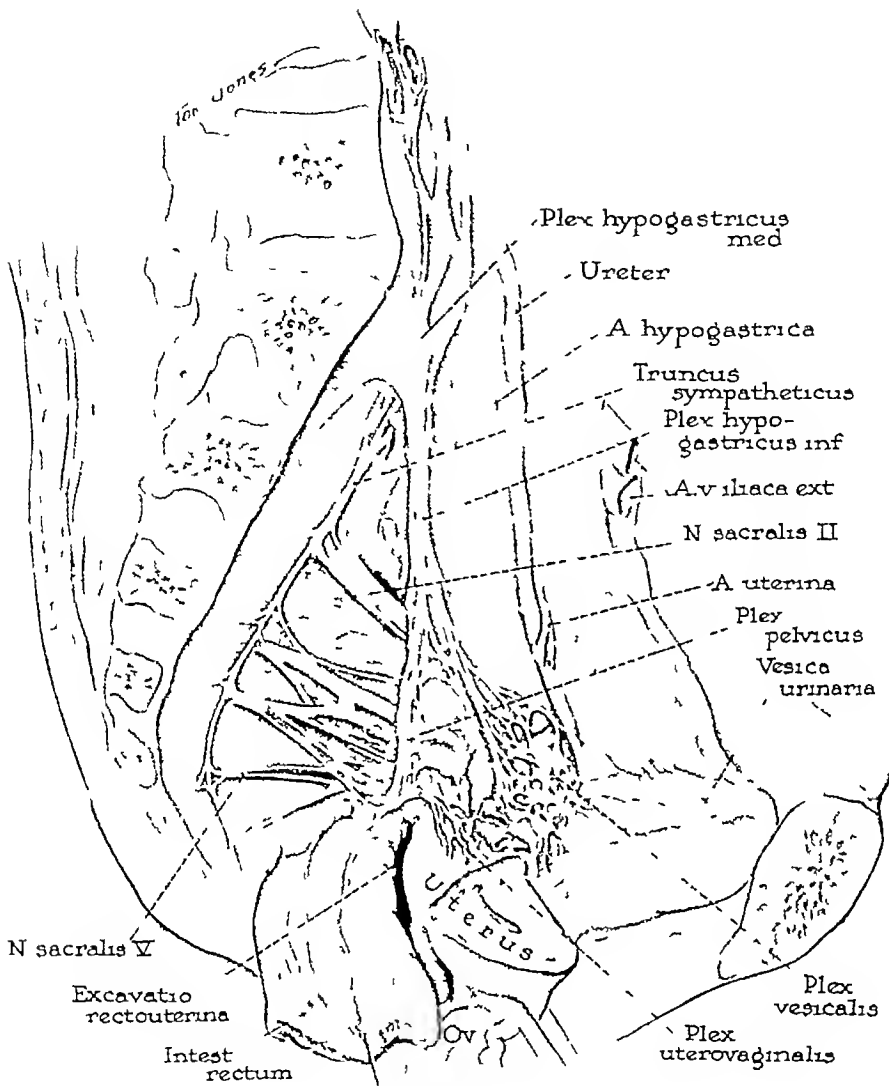


Fig 3 Presacral nerves, deepest fibers View and section as in preceding figure. By further removal of the heavier layer of preperitoneal tissue the communications have been traced between the autonomic nerves and the sacral trunks

#### ANATOMICAL OBSERVATIONS

In the dissected specimen (Figs 1 to 4), the preperitoneal connective tissue was conveniently dissected into two layers (1) a tela fibrosa, in which there is considerable fat at first beneath the peritoneum, decreasing in amount in the lesser pelvis, in this layer there is a scattering, relatively delicate autonomic

nerve fibers, this layer corresponds to that in which the colic, sigmoidal, and hemorrhoidal vessels are housed, (2) a deeper stratum, in which the nerve fibers are supported by delicate connective tissue. The two layers merge at the level of the 2d and 3d sacral segments on the posterolateral wall of the lesser pelvis. The delicate deeper layer of connective

tissue in which the major portion of the nerves lie enmeshed is depicted in Figure 1 only where it closely surrounds the nerves to make them appear heavier than they are.

As stated previously the dissection shown in Figure 1 was purposely made to correspond to the exposure employed in the operation for presacral nerve resection. Although in the living subject one sees chiefly a cubebby retroperitoneal connective tissue in which the nerves are distinguished with difficulty in the dissected body in contrast the majority of nerve fibers depleted are followed readily without recourse to the use of a hand lens.

The autonomic nerve trunks of the superior and middle hypogastric plexuses tend to be located to the left of the midline. In 30 dissections 75 per cent were on the left, 25 per cent were midline none were on the right. This is an additional reason for thorough operative exposure of the nerve bearing tissue on the left a detail of the procedure commonly avoided because of anatomical variability and consequent surgical hazard.

The superior hypogastric plexus becomes the middle hypogastric plexus just below the promontory the latter bifurcates at the level of the body of the first sacral vertebra (Figs. 1 and 2). The inferior hypogastric plexus continues inferiorly downward and lateralward along the pelvic wall. At the approximate level of the 3d sacral vertebra this closely grouped plexus of nerve fibers begins to separate and to anastomose with fibers coursing laterally from the sympathetic chain and from the sacral plexus. The point of union marks the upper limit of the pelvic plexus.

The pelvic plexus shown in the illustrations is 4 centimeters wide 3 centimeters long from the point at which the inferior hypogastric plexus begins to fan out. It is of roughly triangular shape (Figs. 2 and 3). In passing to the rectum, uterus, bladder and other places of distribution, it divides into lesser plexuses, the three principal members of the group being the rectal, utero vaginal and vesical. Each of these lies on the lateral pelvic wall adjacent to the respective organ for which it is named. The uterovaginal and vesical plexuses approach the viscera from below on their posterolateral aspects (Figs. 2 and 3).

The sacral sympathetic chain appears bilaterally from beneath the common iliac vessels at a point 2.5 centimeters lateral to the middle of the promontory (Fig. 1). The chains pass along the lateral surface of either side of the sacrum giving a small branch to each of the sacral nerves. 6 ganglia are visible in the left chain (Figs. 2 and 3) minute fibers are also contributed to the parasympathetic nerves by the 3d to the 5th ganglia.

The *nervus erigens* (parasympathetic *rami viscerales*) consists of three branches from the 2d, 3d and 4th sacral nerves (Fig. 4).

The parasympathetic nerves reach the posterior aspect of the pelvic plexus a distance of 6 centimeters from the midpoint of the body of the 5th sacral vertebra thus forming a wing of nervous and fibrous tissue situated deep to the pelvic plexus and connected with it.

As already described and illustrated in a study of the vessels of the female pelvis, the pelvic plexus of nerves is superimposed upon the vascular network of the broad ligament (7). In the broad ligament at the base of the uterus the nerves can be seen passing over and among the vessels in their course to uterus.

The ureter enters the true pelvis, crossing the common iliac artery at or near its bifurcation into the external iliac and hypogastric arteries (Figs. 3 to 4). At this point the distance between the ureters averaged 7 centimeters in a number of specimens examined this distance however is subject to wide variation. It is at this level that the ureters are most accessible for identification during presacral nerve resection.

#### SURGICAL IMPLICATIONS

Experience has demonstrated that removal of the superior hypogastric plexus is a very satisfactory procedure for the relief of vesical and uterine pain particularly for permanent relief of suffering from primary or essential dysmenorrhea. In this connection it should be borne in mind that pain from the ovaries travels by an independent pathway and is not relieved by presacral neurectomy.

Emphasis should be placed on the fact that the midline incision for resection of the hypogastric plexus must extend to a point 11 above the navel in order to insure a equal

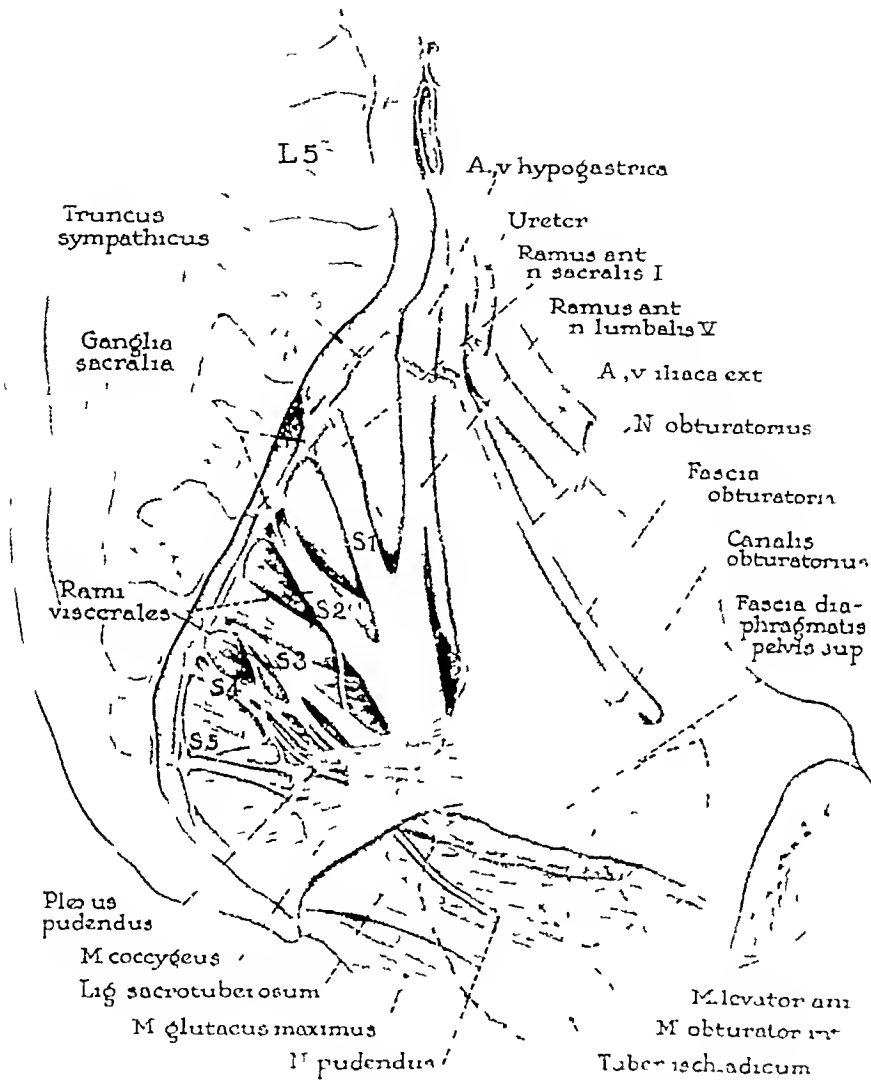


Fig 4 Sacral plexus and related structures. View and section as in Figures 2 and 3. The iliopectineal fascia has now been removed; the pelvic part of the obturator fascia is intact, the superior fascia of pelvic diaphragm remains along the tendinous arch. The iliopsoas muscle is exposed; the levator ani remains along its attachment from body of pubis to spine of ischium; the piriformis is seen deep to sacral plexus; the coccygeus muscle entire; the obturator internus muscle is shown freed of fascia in its perineal part, coursing toward the lesser sciatic foramen; the gluteus maximus is seen as it crosses from sacrococcygeal attachment to pass behind the tuberosity of the ischium. The sacrotuberous ligament is in view, but the sacrospinous ligament is almost completely covered by the coccygeus muscle. The obturator nerve is followed to the foramen from the sulcus between the psoas major muscle and the hypogastric vessels. The lumbosacral trunk and the five sacral nerve trunks are shown. The pudendal nerve is followed along perineal wall, exposed there by removal of the obturator fascia.



exposure. As the operation is usually performed the right ureter is encountered and exposed but it is commonly stated that the left ureter is not usually seen, because it is difficult to expose and is frequently inaccessible behind the sigmoid bowel. As a matter of fact the operation may be made much more thorough and safe, and more extensive, by exposure of the left ureter as well as the right. One proceeds from the region of the right ureter toward the left including all connective tissue overlying the bony wall the dissection being continued until a corded tissue is encountered on the left. This will usually be the superior hemorrhoidal artery (with vein) in close proximity to the left ureter the latter usually being more lateral than the vessels and in a deeper stratum of cellular tissue. The hemorrhoidal vessels are exceedingly important landmarks and are of material aid in locating the left ureter. Our anatomical dissections confirm our clinical experience that removal of all nerve-bearing tissue between the two ureters with emphasis on the tissues to the left is particularly desirable. In view of the fact that pain travels upward from the viscera, the importance of high dissection appears overemphasized whereas wide and thorough dissection below has received too scant emphasis. The tissue to be excised *en masse* includes all accessible retroperitoneal nerve bearing connective tissue of the deeper pelvis which can be removed with safety above the level of the second sacral nerve. A feature of some interest is the fact that the middle sacral artery usually escapes injury not because it is so often rudimentary as has been commonly assumed, but because it is closely attached to the bony structures, and therefore escapes injury with gentle blunt dissection. It is frequently stated that although this operation yields very gratifying results, it is by no means a simple procedure to be undertaken lightly. With this we are in full accord but with exposure of both ureters and detailed technique the hazard is apparently negligible. Further it is stated that there is a tendency to recurrence of dysmenorrhea some years later. In our cases, particular care has been exercised to make thor-

ough extension and there has been no such recurrence.

#### SUMMARY

The surgical anatomy of the hypogastric plexuses has been portrayed exactly as it appears in a typical dissected specimen.

The pelvic autonomic nerves have been shown *in situ* their distribution location, and intercommunications are revealed. The wide expanse of the pelvic plexus, to include the region along the posterolateral pelvic wall and the tissue surrounding the vessels and ureter in Mackenrodt's ligament is an anatomical condition important in gynecology. The implications of this relationship in the etiology of pelvic pain are self-evident.

The distribution of the visceral nerves and their communications with the branches of the parasympathetic *nervus erigens* (*rami sacrales*) from the sacral nerves are described and illustrated the manner in which these several sets of fibers contribute to the broad pelvic plexus (Frankenhauser's plexus) is also shown.

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## LEFT SUBPHRENIC ABSCESS

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IN the vast literature dealing with subphrenic abscess scarcely any attention has been directed toward suppuration beneath the left leaf of the diaphragm. Observations on our own as well as on other surgical services at Mount Sinai Hospital have pointed to decided differences in the anatomical, pathological and clinical features of right and left subphrenic abscess. The great disparity in mortality in The Mount Sinai Hospital series—35 per cent for right subphrenic abscess as compared with 75 per cent for left subphrenic abscess—would alone warrant separate consideration of left subphrenic abscess. Other reasons will be set forth. Our presentation of the subject is based on a study of 33 adequately documented consecutive cases of left subphrenic abscess observed at Mount Sinai Hospital from 1918 to 1947. Fifty-one cases of right subphrenic abscess were observed in the same period. After a brief discussion of the anatomy of the left subphrenic space the 33 cases will be analyzed according to etiology, pathogenesis and pathology, clinical and roentgen features, prognosis and mortality. The operative procedures that are performed will be surveyed and there will be described a one stage transpleural operation for the thoracic variety of left subphrenic abscess. It is hoped that the acceptance of certain principles to be set forth concerning earlier diagnosis and operative procedure will result in some measure of reduction of the present day appalling mortality of left subphrenic abscess.

### ANATOMY

Barnard's simple definition of subphrenic abscess as one immediately beneath and in contact with the diaphragm is adhered to in this discussion. A broad contact is implied. Some authors include under subphrenic abscess, lesions more or less remotely related to the diaphragm, for example, certain pericholecystic or perirenal suppurations. Lesions which incidentally touch the diaphragm usually do not raise special diagnosis and therapy problems which often arise in true subdiaphragmatic abscess, and their inclusion would confuse the issue. Our discussion is confined to abscesses which have their main contact with the under surface of the left leaf of the diaphragm.

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From the time of the basic contributions concerning subdiaphragmatic abscess the anatomical subdivision of the space has been stressed. The left subphrenic space has been defined in terms of its relation to the liver (S,22). The left coronary and triangular ligaments, the falciform ligaments and antero-superior surface of the liver limit the large left anterosuperior intraperitoneal space. The left coronary and triangular ligaments, the posterior surface of the left lobe, and the gastro-hepatic peritoneal fold confine the left posterior intraperitoneal space to the lesser peritoneal cavity. The bare area comprises the superior extra-peritoneal zone. Since the left anterior inferior space is bordered above by the inferior surface of the liver, it should not be regarded as the subphrenic but as the left anterior subhepatic area. In the presence of infection, anatomical demarcations may become indistinct. Furthermore anatomical boundaries may become distorted and a topographic classification as a guide to operative procedures may become useless or even dangerous. According to our study of the cases the conventional division of the left subphrenic space into perihepatic zones is unsatisfactory in the presence of suppuration. About one half of the left leaf of the diaphragm is in contact with the liver, the stomach and spleen occupying most of the remaining space. It will be shown that perisplenic and perigastric abscesses in contact with the diaphragm as broadly as perihepatic abscesses comprise a preponderance of left subphrenic suppurations.

One fundamental anatomical difference between left and right subphrenic abscess should be emphasized. On the right side the liver, a solid organ, not only occupies the entire space but is relatively immobile and anchored in its bare area by fibrous structures, the veni cava and its hepatic tributaries. By way of contrast the left lobe of the liver occupies less than half of the left subphrenic space and is slung from the parietes by peritoneal folds. The other peritonealized structures of the left subphrenic space (spleen, stomach, colon) are even more mobile. Thus, the right lobe of the liver tends to lock up a right subphrenic abscess whereas the organs bordering a left sided lesion are readily displaceable by an expanding suppurative lesion.



Fig. Left subphrenic abscess, complicating appendicitis and peritonitis. Fibra taken in patient in prone position. The unsatisfactory information available because of prone position may be noted.

#### ETIOLOGY AND PATHOGENESIS

All left subphrenic abscesses in our series were secondary to intra-abdominal suppurative foci. Direct extension of infection from nearby organs was by far the most frequent mode of spread into the left subphrenic space. Tracts lined by granulation tissue or actual purulent channels extended from the primary suppurative focus either intra-peritoneally or extraperitoneally in 30 of the 33 cases. Lymphatic extension occurred in 3 instances, following appendectomy and pelvic suppuration, and was thus an infrequent mechanism of dissemination. There is one instance in which the etiology remains unknown. From the history a possible intestinal source may be postulated. The patient's progress has been satisfactory and the source of infection may never be determined. In this connection it should be noted that there were 2 cases in this series in which the etiology was not disclosed until months after the subphrenic abscess was drained.

The most frequent single source of infection was the stomach or duodenum (3 cases). In 2 of these 3 cases the lesion was a perforation situated on the right side. In the 3 remaining cases the lesion was in the fundal portion of the stomach (left upper quadrant). In all there existed perforation either of peptic ulcer or malignant

tumor or of an anastomosis following gastric resection.

Regional abscesses of the left upper quadrant extending into the subdiaphragmatic space were encountered in 18 cases (56 per cent). The etiology in 2 cases was splenectomy. In one a hematoma subsequent to splenectomy for traumatic rupture of the spleen became infected. In the other trauma to the capsule of the pancreas during splenectomy for thrombocytopenic purpura resulted in pancreatic necrosis and the accumulation of the purulent autolyzed material beneath the diaphragm.

It has been asserted that the subphrenic space may be invaded directly by the hematogenous route (27). This was not encountered in our series. However there was a group of 4 cases of indirect invasion by way of perforation of metastatic abscesses of the spleen. In some of these cases the source was a pulmonary abscess with complicating suppurative phlebitis. There is no evidence of direct extension of infection across the diaphragm in these cases. Arribald described the exceptional instance of supradiaphragmatic empyema which perforated the diaphragm to invade the subphrenic space. There appears to be but little justification, however, for the belief that 5 per cent of left and right subphrenic abscesses can follow empyema with retrograde lymphatic gravitation due to blocked hilar lymphatics (8). Schlanger with radio-opaque material, 31 mm by carboline injection, and others have demonstrated free anastomosing lymph channels from the lower abdominal organs to the liver and subphrenic spaces through the diaphragm to the mediastinal and deep cervical lymph nodes. Kuettner demonstrated extensive lymphatic channels in the diaphragm, but reverse flow from within the thorax to the infradiaphragmatic areas was never noted. Clark injected dyes into the mediastinum and was unable to discern retrograde lymphatic drainage through the diaphragm.

Infected retroperitoneal sarcoma situated in the left upper quadrant was the cause of subphrenic abscess in several instances. A distinctive clinical picture may be noted shortly characterizes these cases.

Reference has already been made to the single instance of left subphrenic abscess following left renal tuberculosis. Only after a period of many months (at the time of nephrectomy) was the etiology proved to have been a perforation of the superior pole of the tuberculous kidney.

Left subphrenic abscess followed reoperation of the biliary tract in 3 cases. In one there was direct extension from perforated cholangiect

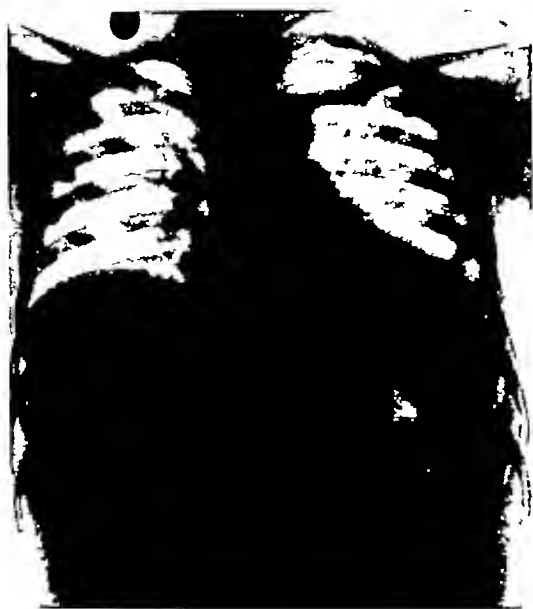


Fig 2 Roentgenogram of same patient in the upright position, taken on the same day. The mass which was made by the subphrenic abscess is to be seen through the gastric bubble.



Fig 3 Lateral view. The forward displacement of the stomach is noteworthy. The outline of the multilocular subphrenic abscess is seen through gastric fluid level. Patient recovered after one stage transdiaphragmatic drainage.

liver abscess into the anterosuperior perihepatic space, and in the other one gravitation of infected bile from perforation of the gall bladder into the laterosplenic aspect of the subphrenic area.

Pelvic suppuration was the etiology in 2 cases. Barnard and Carter have emphasized a left intraperitoneal paravertebral pathway from the pelvis to the left anterior subdiaphragmatic space. In our cases the suppurative tract extended from the pelvis over the left sacral promontory in the retroperitoneum along the iliopsoas, to reach the left diaphragm extraperitoneally.

A study of the cases in this series establishes the fact that there are no pre-existing specific pathways of infection to the left subphrenic space and that suppuration beneath the left diaphragm is contingent upon direct extension from regional areas in most cases. Thus, from the viewpoint of etiology and pathogenesis, emphasis is to be placed on subphrenic abscess as a problem requiring individual surgical approach in individual cases and not operative drainage in accordance with a set plan. In connection with diagnosis, the high incidence of left-sided subphrenic abscess which has been derived from right-sided perforations of stomach or duodenum is worthy of special comment.

#### PATHOLOGY

The differences in the anatomy of the right and left subphrenic spaces, referred to at the outset, account largely for the differences in pathology. On the right side an abscess beneath the right diaphragm cannot readily expand against the massive and relatively immobile right lobe of the liver, and therefore tends to enlarge by elevation of the diaphragm. Elevation of the right diaphragm has thus become a fairly constant phenomenon and perforation of the diaphragm a relatively common occurrence (3, 28). As the diaphragm becomes displaced or balloons upward, contact between the abscess and the thoracic parietes is prone to occur. The simple anatomical configuration of the right subphrenic space leads to a simple monolocular abscess in most cases.

The foregoing features of right subphrenic abscess are mentioned for purposes of contrast with left-sided lesions. The limiting abdominal organs, varied in form and mobile in attachment to the parietes, are displaced as the mass expands. The left lobe of the liver is a decidedly less resistant structure than the right. Thus, elevation of the left leaf of the diaphragm is not to be anticipated as a constant or early phenomenon. As a corollary, supradiaphragmatic invasion with or without perforation is not common. The feature of the path

ology which is of greatest clinical importance is the great variation in the shape, location, and location of left subdiaphragmatic abscess. Each abscess assumes an individual configuration and site within the left subphrenic space. The presence of hollow as well as parenchymatous organs bounding all but the roof of the left subphrenic space often results in a complex irregular abscess cavity which tends to be monolocular only at an early stage. Later it may burrow around both the liver and spleen, compressing and displacing the stomach and bowel and seeping along the peritoneal ligaments to form an intricate multilocular cavity. Of the 30 cases in this series in which the details are known, the abscess had advanced to the stage of multilocularity in 20. The difficulty or occasionally even the impossibility of surgical drainage of such lesions is apparent.

The question of the presence of gas (air) in subphrenic abscess is of clinical import. A fluid level was observed in 2 of the cases of left subphrenic abscess in this series. Wheeler and Jacobs appear to have been the first to state that a subphrenic gas containing abscess only follows perforation of or into the bowel or the bronchial tree. On the other hand, Gatewood has asserted a bacterial origin. The left subphrenic gas containing abscesses in our series resulted from gastrointestinal perforation. It may be added that communication with hollow viscus or a bronchus has existed in all gas containing right subphrenic abscesses in our experience. It is of further interest to note that there were 4 cases of anaerobic streptococcus and Welch bacillus infection in our series of left subphrenic abscess and not one was gas containing lesion.

#### CLINICAL FEATURES

On the basis of review of a vast literature on subphrenic abscess, Ochsen described 3 types of initial manifestations. In the great majority of cases pyrexia with accompanying leucocytosis is the first sign beginning from 1 day to 3 weeks after abdominal suppuration. In a small group the onset is sudden and abrupt (17 of 33). There is a third small group characterized by an extremely slow and insidious evolution (9 of 24). There is a considerable measure of uniformity in the primary clinical manifestations in the 33 cases of left subphrenic abscess. The presenting symptoms were essentially those of the causative suppurative focus and the subphrenic abscess as such could be regarded as having remained asymptomatic for weeks or even months. Only in 7 cases (22 per cent) was the developmental period apparently less than 3 weeks and in these all but one

were instances of free gastrointestinal perforation with gross seepage into the subphrenic area. The evolution in 78 per cent of the cases was either to insidious or indistinctive that there was an average lapse of a month and a half from the initial suppuration to the time of recognition of the subphrenic focus. In 3 instances the interval was an indefinite period of years. During the latent period no constant symptoms or localizing signs were present. The picture of a vague illness with malaise, debility, occasional fever and slight leucocytosis, suggested the possibility of an area of suppuration complicating the original lesion. Emphasis should be placed upon this long unfeeling period because the prognosis of even an adequate and simple operation for subphrenic abscess may be grave when patients are finally operated upon.

Rapidly mounting fever usually marked the transition to the active phase of left subphrenic abscess. The temperature, rising daily to 104 or 105 degrees and paralleled by tachycardia, was the index of the toxic state in 3 patients.

Dry cough, painful breathing, and constant left lower thoracic pain were the most frequent complaints and when unaccompanied by abdominal symptoms pointed to the thoracic type of subphrenic abscess. Physical signs referable to a left sided pleuropneumonic inflammatory process were present in 24 patients, 78 per cent. Emphasis should be placed on the fact that there were no accompanying abdominal symptoms in more than half the cases in which thoracic manifestations existed.

Left upper abdominal pain, tenderness, muscle spasm, and abdominal distention comprised an abdominal symptom complex which distinguished cases from the thoracic subphrenic group. This separate abdominal picture was present, however only in few cases. The site of most intense pain and tenderness proved to be important in revealing the situation of the focus. Combined abdominal and thoracic manifestations were observed in 31 per cent of the cases. In all the lesion was extensive and advanced, suggesting that the combined picture is to be regarded as late stage.

In 7 instances of left subphrenic abscess abdominal manifestations were palpated in the left upper quadrant. In 3, the masses were inflammatory. In 4, malignant. Gastrointestinal roentgenographic studies revealed downward displacement of the colon and medial displacement of the stomach in the neoplastic group. It is said that induration without displacement characterizes the inflammatory group (4) but in at least one case in our series there was considerable displacement of

organs, especially the stomach, by an inflammatory lesion

Special consideration should be given to the neoplastic group in our series. All were retroperitoneal malignant tumors with secondary infection. The clinical course of left subphrenic abscess in these cases differed from the septic state and acute history of the subphrenic abscess associated with a palpable inflammatory mass. There was a period of weakness, dull upper abdominal pain, a sensation of fullness, and partial colonic or gastric obstruction. Thoracic manifestations were minimal. The clinical picture was that of progressive asthenia with incidental fever. A hyperacute picture occurred 12 hours before operation in one case in which there was perforation of the stomach due to direct invasion by the neoplasm.

Referred shoulder pain is held universally to be a constant symptom of suppuration beneath the diaphragm. The supradiaphragmatic pleura, the central portions of the diaphragm, the subphrenic peritoneum, and possibly the superior surface of the liver are reported to be innervated by the sensory fibers of the same metamere as the shoulder (23). Carter (4) stated that shoulder pain was more frequent in left than in right subphrenic abscess. Pronounced shoulder pain was present only in 6 of our cases. In each instance there was an abscess deep under the dome of the left diaphragm. The latter was paretic in 3 patients, but freely mobile in the 3 others.

An elevated, paralyzed diaphragm, rarely absent in right subphrenic abscess, was demonstrable only in 18 of 30 cases (60 per cent) of left subphrenic abscess. The pathology of left subphrenic abscess accounts for the variable response of the left diaphragm. The surgical importance of an elevated left diaphragm warrants special consideration of this feature despite its inconstant occurrence. In the first place, paresis of the diaphragm was usually noted before its elevation. Second, the rise of the diaphragm in left subphrenic abscess may be masked, in the customary posteroanterior film, by supradiaphragmatic effusion. It should be noted that lateral and oblique views may resolve difficulties in interpretation. Careful study of roentgenograms may offer the only basis for the correct diagnosis as well as for a precise surgical approach to a left subphrenic abscess of the thoracic type. Varying degrees of pleural effusion so overshadowed the diaphragm in 7 instances that its position was completely masked despite repeated roentgenographs. In some cases it may be necessary to ascertain the relationship between stomach and diaphragm by

the administration of medication producing gas in the stomach (Sedlitz powder, bicarbonate of soda).

It has been assumed by some that large, left perirenal abscesses are accompanied by a raised diaphragm. Sixty-five perinephritic abscesses from the records of the Mount Sinai Hospital were studied in this connection. An elevated paralyzed diaphragm was discovered in a single instance, a 9 year old child with an enormous suprarenal perinephritic abscess. It is of interest to note that elevation and paralysis of the diaphragm were absent in this case until a late stage of supranephric extension of the abscess.

As already indicated, a left subphrenic gas-containing abscess denoted a serious factor, namely perforation of a hollow viscus, or communication with the bronchial tree (possibly under rare circumstances the existence of gas-forming organisms). The fluid level, separate from the stomach bubble, was demonstrable roentgenologically in 3 patients. In connection with the significance of subdiaphragmatic gas is the fact that fluid levels often can be visualized in the subphrenic spaces for 2 weeks after laparotomy.

#### DIAGNOSIS

According to the features of left subphrenic abscess which we have described, it is evident that the diagnosis of suppuration beneath the left diaphragm may be difficult or even impossible. Thus a significant febrile response referable to infection was absent in 31 per cent of our cases. Thoracic features were lacking in 25 per cent. Suggestive upper abdominal manifestations were wanting in 56 per cent. A thoracoabdominal symptom complex was lacking in two-thirds of the group. Shoulder pain was noted only in 6 cases. Paresis and elevation of the left diaphragm was visualized roentgenographically in only 60 per cent of all cases. In the light of these inconstant clinical and X-ray findings, exploratory aspiration of the left subphrenic space obviously assumes great importance. There are two dangers associated with exploratory aspiration. One is that of pleural contamination and the other of delay in surgical exploration attendant upon negative aspiration. Pus was encountered on exploratory aspiration in 14 of 17 cases which otherwise were puzzling as to diagnosis. Pleural contamination did not occur after aspiration in any of the cases. Aspiration was usually undertaken in the operating room, and the needle was left *in situ* as a guide for the surgical approach after pus was located. It is necessary to emphasize that negative aspiration does not negate pus. In 2 instances necropsy re-

vealed that an abscess was present but was medio-splenic under the central portion of the left diaphragm and thus beyond the usual limits of an aspirating needle. The study of our cases has led us to conclude that exploratory aspiration is imperative in all cases with vague clinical and inconclusive features suggesting suppuration in the left subphrenic space. If a diagnosis and an exact localization can be established, aspiration should be regarded as merely confirmatory.

A relatively early diagnosis was made in 18 patients. Puzzling clinical manifestations in 3 patients rendered impossible a diagnosis of suppuration beneath the left diaphragm until the terminal phase of the infection. Recognition of the lesion might conceivably have been possible in 7 unflagged cases. An elevated diaphragm was noted in roentgenograms in 3 of these patients. Thoraco-abdominal manifestations were suggestive (in retrospect) in other patients.

Precision in the determination of the direction in which the abscess pointed (thoracic or abdominal) was possible in several cases. Localized tenderness was of value in defining the abdominal or the low thoracic variety. The particular shape and site of elevation of the diaphragm made possible an individualized surgical procedure in the thoracic variety of abscess. In other words an accurate transdiaphragmatic approach in all cases of the thoracic form of left subphrenic abscess was made possible by careful roentgenological localization.

#### PROGNOSIS, MORBIDITY AND MORTALITY

Because of the etiology alone, the prognosis of a substantial proportion of all cases of left subphrenic abscess must of necessity be grave, and the mortality high. Difficulty of diagnosis and complicated ramifications of suppurative tracts are additional important factors in morbidity and mortality. In order to present a clear picture of the problem as encountered in our series (and presumably as in other series) the cases were divided into 3 groups: (1) virtually hopeless group (2) unfavorable group (3) favorable group.

The first group comprises 13 out of the 33 cases. Thus, there is an inevitable mortality of almost 50 per cent for left subphrenic abscess. The cases consist of ulcerating malignant tumors, actinomycosis, septicemia from various sources, suppurative pyelonephritis, etc. Exception may be taken to the inclusion of or cases but the great majority if not all, must be classified as hopeless from the viewpoint of cure of the subphrenic abscess. Indeed, the suppurative focus in the left subphrenic region can be regarded as of relatively minor importance in almost all these cases.

The group termed unfavorable comprises 8 cases. In 5 the subphrenic abscess was due to leak at a suture line following partial gastrectomy or suture of a perforated ulcer. Of the 3 remaining cases, might have been favorable for drainage but the patients entered the hospital in late phases of the infection. The third case was an 85 year old man operated upon for vesical stone in whom the autopsy revealed an unsuspected subphrenic abscess following an equally unsuspected perforation of the gall bladder.

Thus, in 21 of the 33 cases on which this study is based the prognosis was either hopeless or so nearly hopeless that recovery could not have been anticipated in most, if not all, regardless of correct diagnosis and the institution of correct therapy.

The 12 remaining cases present features which justify their classification in a group with favorable prognosis. In only 1 instance was there a question of a perforation of a gastric carcinoma. As compared with the previous group there was but 1 case in which a subphrenic abscess followed subtotal gastrectomy and in this instance there was no leak from the suture line. An examination of the causes of death in this group is particularly instructive. The diagnosis of subphrenic abscess was not made during life in 3 of the 4 fatal cases. In 1 the subphrenic abscess followed splenectomy for thrombocytopenic purpura, the diagnosis was suspected but not established. The same was true of a second case. In the third case, the subphrenic abscess followed the suture of a perforated ulcer. During the postoperative course, a subhepatic abscess was drained through an abdominal incision, but the subphrenic component remained undrained. The fourth death was due to inanition following ileostomy the subphrenic abscess having been adequately drained. Thus, the evidence points to the likelihood of recovery in the great preponderance of cases of left subphrenic abscess in the favorable prognosis group if the diagnosis is made. The rôle of the surgical procedure in relationship to recovery will be discussed under the next caption.

#### RELATIONSHIP OF THE OPERATIVE PROCEDURE TO THE RESULT

Regardless of the ultimately bad prognosis in many cases of left-sided subphrenic abscess, the immediate results of the operative procedures which were employed should be surveyed. First, the results of two stage transpleural transdiaphragmatic operations will be considered. The course between the two stages was usually characterized by increased toxemia, varying degrees of shock, and increase in abdominal and thoracic

manifestations The separation of pleural adhesions at the second stage operation resulted in pleural contamination in almost all the cases According to our study of the results of the two stage transpleural transdiaphragmatic operation this operation should not be employed for left subphrenic abscess

A transthoracic *subpleural* drainage was performed in 5 cases with satisfactory immediate results In 2 additional cases the pleura was entered at the bottom of the costophrenic sinus, sutured, and traversed in a one stage drainage with satisfactory result Thus, a subpleural approach through the bed of or below the 12th rib was adequate for drainage in the cases in which it was employed Emphasis should be placed on the fact that the operation was chosen only when the evidence indicated that the abscess could be directly approached at the level of the 12th rib There can be added a case which properly belongs here, one in which a subphrenic abscess situated retroperitoneally was satisfactorily drained by a simple lumbar incision

A one stage transthoracic *transpleural* drainage of left subphrenic abscess of the thoracic type was performed in 9 cases with satisfactory immediate results in 8 cases Empyema occurred postoperatively in only 1 case in which the technic to be described was employed As compared with the previous group emphasis should be placed here on the fact that the operation was chosen only when the evidence indicated that the abscess was pointing thoracically

Drainage was found to have been inadequate in the few instances in which transperitoneal operations for subphrenic abscess were employed, but conclusions cannot be drawn from this small series of cases

From the foregoing it is clear that there is a definite relationship of the operation to the immediate result regardless of the fact that the ultimate prognosis is poor in many cases of left subphrenic abscess There are 2 satisfactory procedures and the choice should be based on the direction in which the abscess points To follow slavishly either method regardless of the site of the abscess is illogical Concerning the approach via the twelfth rib, attention should be called to the fact that the pleural space can be easily entered at this level unless it has been sealed off by inflammation The danger lies not in traversing the open pleura, but in not recognizing free pleural entry or in ignoring slight pleural entry As will be shown, the pleural space can be sealed off safely in a one stage operation but an inadvertent (or deliberate) entry not adequately shut off may (and probably will) result in a fulminating empyema

#### ONE STAGE TRANSPLEURAL TRANSDIAPHRAGMATIC DRAINAGE OF LEFT SUBPHRENIC ABSCESS

In view of the immediate good results of one stage transpleural operations in this series, particular consideration should be given to technique Although the principles apply with equal force to a right-sided subphrenic operation, the special features of the left-sided lesion make imperative a meticulous attention to details Methods of transpleural drainage which have been described by Trendelenburg, Elsberg, Lockwood, and McWhorter, do not provide a sufficiently complete sealing of the free pleural space In the following technique we wish to place special emphasis on the double tier of sutures between diaphragm and thoracic parietes The thoracic approach is made over the assumed site at which the abscess is nearest the thoracic parietes This usually proves to be the 7th or 8th rib in the anterior or midaxillary region A liberal section of the selected rib is subperiosteally excised The pleural space usually situated immediately above the costophrenic sinus is traversed If the space is free, the exposed diaphragm is drawn into the wound The diaphragm is sutured securely by chromic gut to the musculature bordering the thoracic incision The sutures are placed in an upper and lower row By means of these sutures, the free pleural space is entirely shut off except at the anterior and posterior limits where the rib ends are situated The next step is the incision of the diaphragm between the two rows of sutures The diaphragm is incised and the cut margins are grasped and drawn up over the first tier of sutures Particular pains are to be taken to shut off the exposed pleural surfaces at the cut ends of the rib at the anterior and posterior limits of the exposure A second tier of sutures is now placed between the cut margins of the diaphragm and the musculature of the thoracic parietes, thus approximating the diaphragm to the chest wall over the first tier When these sutures are tied, the rib ends are completely covered and the pleural space completely shut off If pus should escape at the time of the incision through the diaphragm, prompt drawing up of the margins of the incised diaphragm suffices to prevent significant infection of the pleural space Nevertheless, the suture line should be adequately covered by a ring of iodoform gauze before proceeding with the evacuation of the subphrenic abscess The incision in the diaphragm should be fully adequate as a pathway for thorough visualization and drainage of all the infected areas The operation can be regarded as complete only after a wide opening and tamponade of all collections of pus have been carried out



## SUMMARY

1 The various organs bordering the left subphrenic space, and their mobility render more complex the problem of diagnosis and treatment of left subphrenic abscess, as compared with the right.

2 Left subphrenic infections only followed antecedent intra-abdominal infections in this series. The almost invariable pathway of spread into the subphrenic space was by direct extension. Lymphatic dissemination played scarcely any rôle in infection of the left subphrenic space. Right-sided gastroduodenal perforation was an unexpected cause of left subphrenic abscess.

3. Clinical manifestations of left subphrenic abscess, usually vague and sparse, often appeared relatively late in the course of disease. Indirect evidence of thoracoabdominal manifestations were usually more significant than direct signs of a subphrenic abscess. A raised parietic left diaphragm was conclusive evidence but was only occasionally present. Roentgenological studies of the diaphragm in special positions, particularly lateral and oblique positions, are of importance in revealing the position of the diaphragm as well as the presence of the subphrenic shadow of the inflammatory process or abscess.

4. Exploratory aspiration is often imperative in order to establish the diagnosis. The study of the roentgenogram should be the chief guide to the site of aspiration. Special emphasis is placed upon the possibility of the existence of a subphrenic abscess despite repeated negative aspirations and upon the question of desirability of an exploratory operation under such circumstances.

5. In the operative treatment of left subphrenic abscess, a subpleural approach is advocated for abscesses of the abdominal type. For thoracic type of subphrenic abscess transpleural transdiaphragmatic approach is advocated.

6. A two stage transpleural transdiaphragmatic operation was attended with poor results. A satisfactory one stage operation is described in which double sealing of the free pleura by two tiers of diaphragmatic sutures is featured.

7 The inclusion of right and left subphrenic abscess under the single caption of subphrenic abscess is not desirable because of the difference in etiology pathogenesis, and mortality. Analysis of 33 cases of left subphrenic abscess reveals an exceedingly high mortality, which is unavoidable in great part because of the irremediable causative lesions.

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# THE MANAGEMENT OF ABNORMAL VAGINAL BLEEDING

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**A**BNORMAL vaginal bleeding is a gynecological complaint frequently encountered by the general practitioner. All age groups are represented, from before puberty, through the reproductive cycle, at the menopause, and in the postclimacteric period. The average physician often undertakes the management of such bleeding as an office procedure, and after a period of time often sends the patient to a hospital. Over 40 per cent of 8,216 patients admitted to the gynecological service of the Woman's Clinic of the New York Hospital had a history of abnormal vaginal bleeding, while in approximately half of these menorrhagia and metrorrhagia constituted the chief complaint. The actual loss of blood over long periods of time, the associated weakness and debility, the inconvenience to the patient of increased and continued flow, as well as the danger of an underlying malignancy, make such abnormal bleeding a most important problem.

The causes of abnormal bleeding are numerous and have been given repeatedly in the literature. Included are myomas, polyps, ovarian tumors, cervical and vaginal erosions and tumors, carcinoma, and the gestational states including ectopic pregnancy and abortion.

The relative frequency of occurrence of the causes of bleeding varies markedly with the age groups. Shortly after birth, withdrawal of the maternal estrogens may cause vaginal bleeding in the offspring, while during the first decade of life ovarian tumors are the predominant cause, tumors of the pituitary, adrenal and pineal coming next in order of frequency. Only very rarely do we encounter malignancy of the genital tract in infancy and childhood. During the second decade, or period of sex development, endocrine imbalance assumes first importance, to be followed by inflammatory lesions, and occasionally by benign ovarian tumors. Myomas and malignant tumors are almost too rare to be mentioned in this age group. In the childbearing period, gestation, pelvic inflammatory disease, myomas, cysts of the ovary, endocrine disturbances and malignant growths of the genital tract, con-

stitute the order of incidence. In the fifth and sixth decades of life, menopausal bleeding and malignant growths are the outstanding causes. Carcinoma of the cervix is particularly prevalent in the fifth and carcinoma of the body of the uterus in the sixth decades. After the age of sixty, malignancy and benign polyps are the outstanding causes, with carcinoma of the cervix, corpus uteri or ovaries to be kept in mind. Granulosa cell tumor of the ovary may precipitate bleeding, as do also atrophic vaginitis or inflammation.

It is quite apparent, then, because of the variety of etiological factors, that in all cases of abnormal bleeding a thorough search for the cause must precede any and every attempt at treatment. With the development and growth of "endocrine clinics" in virtually all departments and specialties of medicine it has become more and more evident, during the past ten years, that this all important prerequisite of thorough examination, including pelvic examination by a competent gynecologist, and whenever indicated vaginal smears, biopsy or curettage, is not followed. How often these days do we not see women who had had all types of indiscriminate "endocrine therapy," without a correct diagnosis of the cause of the bleeding? It is our opinion that before reliance is placed wholly on pregnandiol excretion values and the quantitative results for estrogen and pituitary hormone levels, organic causes of bleeding *must* be eliminated. Unfortunately, the urine and blood determinations for the various hormones are as yet not of sufficient practical value to indicate the proper treatment in the majority of cases.

A careful history of the character and amount of bleeding, thorough pelvic examination, under anesthesia if necessary, visual inspection of the cervix, with biopsy if in the least suspicious, vaginal smears and examination of the endometrium, by either biopsy or curettage, are our best means of establishing a diagnosis. By these methods, cervical and uterine polyps, chronic cervicitis and endometritis, myoma uteri, hyperplasia of the endometrium, salpingitis, cysts and tumors of the ovary, and malignant disease of the cervix and corpus may be diagnosed. The treatment of each of these, with the possible ex-

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TABLE I.—CAUSES OF VAGINAL BLEEDING IN  
GYNECOLOGIC PATIENTS SEPTEMBER 1  
1932 TO DECEMBER 31 1940

	Number	Per cent
Undetermined	865	24.9
Myoma uteri	854	24.6
Hyperplasia endometrium	534	5.3
Polyp, endometrial	344	9.9
Cervicitis and erosion	377	4.4
Polyp, cervical		6
Irregular shedding	35	3.8
Adenomyoma	102	9
Carcinoma cervix	75	2.2
Carcinoma uterus	71	
Endometritis	5	2.3
Sarcoma uterus	1	0.
Total	3,468	99.6
Total number of patients	8,716	
Patients with bleeding	3,468	41

ception of endometrial hyperplasia, is fairly specific, although unfortunately not always curative.

From Table I it will be seen that in only three-quarters of our gynecological patients with abnormal vaginal bleeding was a definite diagnosis established while in the remaining one-quarter or 865 women, we were unable to determine the etiology of the bleeding. Of the known causes, myoma uteri accounted for the hemorrhage in 854 women, or 24.6 per cent of the total series, while hyperplasia of the endometrium ranked next in order of frequency being responsible for 5.3 per cent of the cases.

The term functional bleeding has been used with greatly varying interpretations. It is our contention that this term should be limited to those cases in which no organic lesions, such as malignancy myomas, polyps, or inflammation are present. If used in this limited sense, functional bleeding would include the groups cause undetermined, hyperplasia, and irregular shedding in Table I, and thus account for 44 per cent of all the cases of abnormal bleeding. It may be advisable, as we gain more information, to limit even further the use of this term, and confine it to the group of causes unknown. In Table II we have included under functional bleeding hyperplasia and irregular shedding. In only slightly over one-third of these patients with functional bleeding, was hyperplasia of the endometrium found at operation, while irregular shedding of the endometrium accounted for less than 10 per cent. The diagnosis was undetermined in over half of these patients.

The treatment of the gross pathological causes for bleeding will not be discussed in this paper

It must be stressed however that no treatment of abnormal vaginal bleeding should be under taken unless and until a thorough investigation of the patient has been made, benign as well as malignant tumors ruled in or out, and a diagnosis if possible, established.

If the menorrhagia, metrorrhagia, or polymenorrhea is disclosed by the history and physical examination, vaginal smears and endometrial biopsy may reveal a hyperestric condition. Granting that organic causes are not present, dilatation and curettage will often effect a cure. It is, of course, essential that any thyroid deficiency as shown by the basal metabolic rate be corrected. This applies likewise to the body weight and anemia, in which cases proper dietary measures may be indicated. Should dilatation and curettage, often repeated, once or twice prove of no avail, endocrine therapy may be tried. It is seldom that radical treatment is instituted.

From Table III it is noted that in 94.1 per cent of the patients with hyperplastic endometrium, the operative treatment was minor i.e., dilatation and curettage. In only 5.9 per cent of these patients was a major operation performed, and in most of these the hyperplasia was a secondary finding. This holds almost equally true for the patients who showed irregular shedding of the endometrium. In the majority or 66.6 per cent, of our gynecological patients with abnormal bleeding, dilatation and curettage alone was performed. Furthermore, a striking comparison is seen between the organic and functional bleeding cases: minor operative procedures were performed in about half of the former and in 80 per cent of the latter.

Not infrequently no gynecological pathology can be found to explain the bleeding. This occurs, as shown in Table I, in about 25 per cent of our patients. These cases usually have had hormonal substitution therapy often without effect except perhaps a depletion of the patient's finances. It should also be borne in mind that hypertension per se may be an accessory factor in abnormal uterine bleeding. It seems desirable to scrutinize certain known causes of bleeding elsewhere in the human body i.e. skin purpura.

TABLE II.—CAUSES OF FUNCTIONAL  
BLEEDING

	Number	Per cent
Undetermined	865	50.3
Hyperplasia endometrium	534	34.8
Irregular shedding	35	8.8
Total	1,434	99.9

bleeding gums, and melena, and see if they can be used to explain certain cases of abnormal vaginal bleeding

The reason for such a departure from the conventional consideration of menorrhagia and metrorrhagia is represented by a small but important nucleus of 20 patients with uterine bleeding, ranging in age from 15 to 47 years of age. These patients were investigated from the standpoint of deficiency in vitamins C and K. There is no doubt as to the relationship of these vitamins to the bleeding and clotting mechanism. Very little attention has been paid to vitamins in the literature from the standpoint of uterine bleeding, probably because they have been overshadowed by the endocrines both theoretically and therapeutically.

Vitamin C and prothrombin determinations were performed on the 20 patients and the results are shown in Table IV. The average value for vitamin C was 0.43 milligrams, according to the Mindlin and Butler technique (normal value, 5-14 mgm). The range varied from 0.0 to 1.1 milligrams, with 70 per cent of the patients below the normal range of 0.5 to 1.2 milligrams. The few cases with normal values invariably had a low prothrombin concentration, and vice versa. The average prothrombin concentration in our 20 patients was only 50 per cent of normal, it was below normal in 79 per cent. In these determinations we employed the Warner, Brinkhous, and Smith technique by which normal patients have a range of 70 to 100 per cent. The majority of our bleeding patients were below the normal range.

What rôle, if any, does a deficiency in vitamins C and K play either separately or jointly in producing abnormal vaginal bleeding in nonpregnant women? Knowledge of the state of the endometrium is important, and every type of endometrium was represented in the 20 patients as follows: proliferative, 5; secretory, 7; hyperplasia, 6; and endometritis, 2. Several had associated pathology such as myomas or polyps. What is the basis for the bleeding in these patients with evidence of hypovitaminosis C and K?

Giedosz and Rychlik report that scorbutic guinea pigs do not develop ovarian follicles

TABLE IV—INITIAL CURETTAGE AND SUBSEQUENT TREATMENT AND COURSE IN 495 PATIENTS WITH "FUNCTIONAL BLEEDING"

Treatment or course	Causes of Bleeding			Number of cases	Per cent
	Undetermined	Hyperplasia	Irregular shedding		
One curettage or more	153	109	21	283	57.2
Curettage and menopause	38	33	8	79	15.9
Curettage and pregnancy	25	18	1	44	8.9
Curettage and endocrine therapy	3	19	0	22	4.4
Curettage and radical therapy*	24	41	2	67	13.5
Total	243	220	32	495	99.9

\*Patients over 40 years of age.

Deficiency in vitamin C makes those present undergo atresia. Normally, the corpus luteum contains large quantities of vitamin C according to both Ley and Vogt. Biskind and Gluck obtained large quantities of vitamin C in the corpora lutea of cows and suggested that it was necessary for the formation of progesterone. Mendive and Deulofeu discovered large amounts in the hypophysis and thyroid gland. However, there is not sufficient evidence to justify the theory that deficiencies in vitamin C can alter the hypophyseal-thyroid-ovarian relationship and so indirectly account for functional bleeding. It may perhaps play a more direct rôle on the spiral arteries of the endometrial glands allowing bleeding to take place much as bleeding gums, nosebleeds, and skin bruising occur in patients with a deficiency in these vitamins.

The rôle of vitamin K in maintaining a satisfactory prothrombin concentration is now well established. The importance of prothrombin in the clotting mechanism needs no discussion. It is conceivable that the onset of bleeding precipitated by a normal menstrual cycle might be prolonged or unusually heavy if an inadequate amount of prothrombin or vitamin C is not available. In this era of drug-counter eating, with a half hour for lunch, the nutrition of these women is certainly below par. Some of these patients also gave a history of using mineral oil and olive oil. Singleton employed dehydrated young grasses for its vitamin K content in the treatment of menorrhagia with satisfactory response. His experience together with our use of vitamins C and K seem to indicate that these vitamins have therapeutic value in this condition.

The use of vitamins C and K was limited to the 20 patients referred to. Cevitamic acid, 100

TABLE III—TREATMENT OF "FUNCTIONAL BLEEDING"

Causes	Operations		Non-operative
	Major Per cent	Minor Per cent	
Undetermined	14.6	69.9	15.3
Hyperplasia endometrium	5.9	94.1	0.0
Irregular shedding	11.9	88.1	0.0

TABLE V.—TYPES OF TREATMENT EMPLOYED IN 372 PATIENTS WITH FUNCTIONAL BLEEDING

Treatment	Total number of cases	Patients cured as shown by follow-up period of 12 years	
		Number	Per cent
Curetting	26	26	100
Radium	29	26	89.7
Hysterectomy	73		100.0
X-ray			100
Hormones	13		13.3
Total	771	269	

milligrams daily orally and 100 cubic centimeters of orange juice were given until the vitamin C level in the blood was normal. Vitamin K was given hypodermically until a satisfactory prothrombin concentration was obtained, to be followed by oral administration of vitamin K. The follow-up results are as follows. Of 8 cases treated with vitamin C and K following curettage 6 were definitely improved, as shown by follow-up for 3 to 15 months. In 2 it is too early to determine result. The beneficial value of the curettage alone is, of course, to be borne in mind. Of the untreated control cases, 5 improved following hysteromyomectomy or radium, 3 were not improved, and in 4 it is too early to state result.

From these considerations, it would appear that an accurate and complete history including dietary habits, is of great importance. As stated, a careful pelvic examination is imperative in addition to the general physical examination. Many practitioners hesitate to examine the female genitalia because of supposed consideration for the patient, while some postpone examination while vaginal bleeding is present. Such delay means further blood loss, and the possibility that the patient may not return for examination. We have no hesitation in examining the bleeding patient on the first visit unless pregnancy is suspected.

It has been our policy to admit bleeding patients to the hospital for a diagnostic curettage regardless of age or underlying gynecological pathology before instituting medical treatment. An occasional patient with an obvious tumor is subjected to laparotomy without the preliminary curettage. However the endometrium is scrutinized in the operating room before the abdomen is closed.

Many patients come to us from physicians after unsuccessful attempts to correct the bleed-

ing with hormonal injections or even x-ray irradiation, without a preliminary curettage having been performed. Needless to say many of these had a malignant neoplasm. Such practice cannot be condemned too strongly.

In 1938 we studied 493 patients with functional bleeding. We have completed a follow-up study on these patients, and the types of treatment with results are presented.

From Table IV it will be noted that every patient had an initial curettage, primarily of course as part of the diagnostic procedures. Thereafter, a certain number (15.0 per cent) passed through an uneventful menopause; 8.9 per cent had subsequent pregnancy which was undoubtedly of assistance in effecting a cure; endocrine therapy was given to 4.4 per cent, and 13.3 per cent (over 40 years of age) had radical treatment. The radical treatment consisted of the intra-cavitary administration of radium, or hysterectomy or the use of x-rays.

The follow-up results in 372 of the 493 patients are shown in Table V. It will be seen that curettage alone gave a cure rate of 71 per cent. The number of patients treated with hormones is too small to permit of any definite conclusion. The small percentage of our patients treated with endocrine is to be explained on the basis of the unsatisfactory results we obtained during the early years of the period studied 1931 to 1938. In those days we relied primarily upon antefollicular-S and pregnancy urine extracts. It is only fair therefore, to state that as the newer preparations (progesterone, stilbestrol, etc.) have appeared, an increasing number of patients with functional bleeding have received endocrine therapy. Since then, a sufficient period of time has not elapsed for a final evaluation of our end-results in endocrine treatment.

In Table VI is given the distribution of patients receiving one, two, three, or more curettages. Of significance is the fact that a far smaller percentage of cures is effected after two or even smaller after three or more curettages, as compared with the results after one curettage, 71 per cent.

Hysterectomy is, indeed, radical treatment for abnormal vaginal bleeding of the functional type. It is necessary to stress the dangers, as well as the sequelae of such radical treatment, especially in the woman in her second or third decade of life.

#### SUMMARY OF TREATMENT IN FUNCTIONAL BLEEDING

**Curettage.** In the treatment of functional bleeding the first step is curettage. This is essential to

the diagnosis of the condition and is often followed by improvement, as shown in Tables V and VI. Reviewing 495 cases of functional bleeding which had occurred in our gynecological service during 6½ years ending December 31, 1938, and followed up to March 1, 1942, we find that curettage alone resulted in cure or definite improvement in 71 per cent. Curettage plus other methods of treatment gave improvement or cure in varying percentages, as outlined here. The other methods of treatment involve the use of thyroid, snake venom, hormone, and vitamin administration, radiation, and hysterectomy.

**Thyroid** There can be little doubt that a low basal rate is at times associated with uterine bleeding, due to the close interrelationship of the various endocrine glands, pituitary, thyroid, adrenals, and ovaries. It is, therefore, evident that any hypofunction of the thyroid gland should be corrected.

**Vitamins** There is little doubt in our minds that a deficiency in vitamins C and K plays a rôle in the production of excessive uterine bleeding in certain patients, in whom all other causes of bleeding are absent. It may be that such a deficiency is at times operating in conjunction with a hormone imbalance. It is advisable, therefore, that in such cases, in which the usual endocrine therapy fails, the blood levels C and prothrombin be determined. Should a definite deficiency be present, an adequate supply of C and K, in the form of cevitamic acid (100 mgm daily), orange juice and synthetic K (from 5 to 50 mgm orally or intramuscularly) be administered to the patient.

**Snake venom** Snake venom acts upon the walls of the arterioles, decreasing or controlling bleeding in certain cases. Moccasin venom in 1:3000 dilution is given subcutaneously daily in doses starting with ½ cubic centimeter and increasing slowly to 1 cubic centimeter. We have had many failures with this method, but do use it in certain cases in which other therapy fails. The results are varying, and do not permit a definite conclusion, although we may state that we have had improvement in some patients treated with snake venom, after previous failures with other types of therapy.

**Radiation** In our opinion, x-ray treatment should be used only in women beyond the child-bearing period and in whom other forms of therapy are of no avail. It is not our practice to attempt to regulate menstruation in girls or young women by radiation, because of the uncertainty of the relationship between dosage and result. On the other hand, Pemberton, as well as Keene and Payne, reported good results in young women

TABLE VI—ONE TO FOUR YEAR FOLLOW-UP RESULTS AFTER CURETTAGE ONLY IN 283 PATIENTS WITH "FUNCTIONAL BLEEDING"

Number of curettages	Number of patients			Total
	Cured	Improved	Not improved	
1	168	22	34	224
2	31	2	15	48
3 or more	2	1	8	11
Total	201	25	57	283
Per cent	71.0	8.8	20.1	

with small dosages of radium, ranging from 200 to 400 milligram hours. We have hesitated to resort to this form of treatment in women not close to, or at, the menopause. When we have used radiation, it has been confined to those past the childbearing period and in dosage sufficient to cause cessation of ovarian function, usually 1500 milligram hours of intracavitary radium. As shown in Table V, bleeding recurred in 3 patients receiving radium. If x-ray radiation is used for the production of permanent amenorrhea, the dosage is usually about 400 r through two portals, one suprapubic and one sacral. We have not resorted to radiation of the pituitary gland for the control of functional bleeding.

**Endocrine therapy** There is evidence to support the conclusion that a hyperestrin condition or a deficiency of progesterone is associated with certain cases of functional bleeding, and thus there exists a rational basis for endocrine therapy in this condition.

This type of therapy may be briefly grouped as follows: (1) anterior pituitary extract, (2) chorionic gonadotropic hormones obtained from pregnancy urine and pregnant mares' serum, (3) sex hormones, the estrogens and progesterone, (4) androgens.

Experience with anterior pituitary extracts is too limited to allow any concrete statement at the present time. A few authors, including Severinghaus, Mayer, and others, have reported short series of cases with encouraging results. Our own experience has been disappointing and at present we are not using these extracts. The same may be said for pregnancy urine, or antuitrin-S, or follutem. There is also doubt in our minds as to the efficacy of pregnant mares' serum.

The best results with endocrine therapy appear to have been obtained with the female sex hormones, estrogen, and progesterone. The natural estrogens (estrone, estradiol, estriol) and also the synthetic drug stilbestrol, and the corpus

luteum hormone progesterone have been used in combinations by some, while others rely mainly on the latter. Estrogens, or stilbestrol alone likewise have been employed, as we believe misguidedly.

The combined therapy consists of a course of estrogens followed by progesterone. The procedure in general, is to start 6 or 7 days after the cessation of bleeding with 10,000 to 20,000 international units (I U) of estrogen daily for a period of 2 weeks, after which progesterone (5 I.U.) is given daily for one week, or until bleeding occurs. This type of treatment, supportive in character tends to bring about normal menstrual cycles and so control the excessive bleeding. It must be pointed out that the menstrual cycle is normally fairly irregular and such cyclic endocrine therapy in many instances would be most inadvisable except when one deals with excessive bleeding (functional) or marked menstrual irregularity which is associated with sterility.

Several recent reports have appeared on the use of the nonhormonal drug stilbestrol in the control of functional bleeding. Palmer in a study of 31 patients, advises 1 milligram of diethylstilbestrol daily for 7 days, then 5 milligrams daily for 7 days, and then smaller amounts (0.3 mgm.) daily for 10 days, or until bleeding starts. Some advise even larger doses of this drug given over longer periods. We have had no experience with stilbestrol in the treatment of functional bleeding. We are as yet not convinced that this form of therapy is devoid of all danger.

We have relied more on progesterone treatment in these cases of estrogenic (anovulatory) bleeding. It is our practice to give 5 milligrams of progestin daily for several days before the expected period. Some cases respond to this therapy.

There does not appear to be sufficient evidence at the present time for the use of androgens in the treatment of functional bleeding in the young woman. It should be stated, however that Geist and his coworkers report favorable results in a fairly large series of cases. The effects of the androgens are due to their stopping or overriding of ovarian function, and so the danger of virilization should be borne in mind.

#### CONCLUSIONS

1. A definite diagnosis as to the cause of uterine bleeding is essential to proper treatment.

2. A complete history, thorough physical examination (including pelvic examination and visualization of the cervix) vaginal smears, and

endometrial biopsy or curettage are essential to accurate diagnosis.

3. Vitamin C and K determinations may reveal marked deficiencies which in certain cases of undetermined etiology may be responsible for the excessive bleeding.

4. A basal metabolic rate determination may indicate hypothyroidism, which likewise may be linked with the etiology of the bleeding.

5. Proper treatment must be directed to the cause of the bleeding, if that is established. Cervical erosions, polyps, myomas, genital malignant growths, and pelvic infection must be treated, if found to be the cause of the bleeding.

6. If deficiency of thyroid secretion or of vitamins C and K is present, these must be corrected.

7. In functional bleeding dependent upon by perestrin conditions, endocrine therapy either complementary cyclic treatment (estrogens and progesterone) or progesterone is indicated.

8. In the control of functional bleeding, radiation therapy should be reserved for the woman past the childbearing period (40 years of age).

9. Hysterectomy should be our last resort in the treatment of functional bleeding and, like radiation, used only in the older group of women.

10. It should be borne in mind that the menstrual cycle may be, normally quite irregular and also that so-called "functional bleeding" may be self limited.

11. The routine use of endocrine preparations for the control of uterine bleeding, without an accurate diagnosis as to the cause of the hemorrhage cannot be too strongly condemned.

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# ZINC PEROXIDE DRESSING FOR POSTOPERATIVE ANORECTAL WOUNDS

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**O**PERATIONS in the anal canal are often radical and leave large raw surfaces. False union of these surfaces tends to produce a stenotic condition of the anal canal. Especially is this true when a radical operation is done for the removal of large internal hemorrhoids. Our purpose, therefore, is to employ a postoperative dressing which will provide the maximum assistance in the management of these cases, particularly by reducing the local infection and the tendency to false union of the wound edges.

The ideal postoperative packing for the canal ought to possess the following characteristics. It should not adhere to the raw surfaces, it should be easy to remove without causing oozing, bleeding, or pain due to its adherence to the raw surface, it should prevent the false union of the raw surfaces not only because of its presence but by the deposition of solid particles, which will come away as the wound heals, it should not overdilate the anal canal, it should be astringent and, therefore, mildly hemostatic, and it should be antiseptic against the pathogens, especially the anaerobes.

In an earlier publication, one of us (C V B) described the ambulatory operative treatment of 194 selected cases of chronic fissure, cryptitis, hypertrophied papillae, simple uncomplicated fistulae of the anus, and single internal hemorrhoids operated upon under prolonged local anesthesia in oil (neothosol, etc.) The cases were analyzed with respect to reactions, complications, healing time and the number of dressings, and the follow-up results were presented. In the Vanderbilt Clinic, Presbyterian Hospital, we have operated upon 430 of these patients, and the safety and efficacy of this type of anesthesia have been confirmed.

The purpose of the present report is to analyze our results from the standpoint of the kinds of postoperative packing which has been used in these ambulatory cases and to evaluate the use of zinc peroxide for this purpose, based upon clinical experience.

Three types of packing have been used: iodoform, plain gauze and plain gauze soaked in a suspension of zinc peroxide in plain water or saline.

Iodoform gauze was first used. Its only definite advantage is its deodorant property. Its disadvantages are principally that it is irritating, it can cause superficial necrosis, it may cause pain, it produces an iodoform toxicity in some patients, it adheres firmly to the wound and often causes oozing and sometimes bleeding when it is removed. Furthermore, this gauze has no proved appreciable bactericidal action. Its use has been discontinued because of these undesirable characteristics.

Plain gauze packing was then used, but it produced, even in 24 hours, a malodorous condition which was unpleasant. Furthermore, its removal occasionally left an oozing, bleeding surface. Because of these disadvantages, its use was discontinued.

Meleney in 1935, in an especially fine piece of work, established the value of zinc peroxide in the management of certain hitherto uncontrollable anaerobic and microaerophilic infections. At the same time he suggested its use in operations involving the rectum. Meleney states that zinc peroxide is not locally irritating to the tissues, or in any way toxic to the body as a whole, and that it may be safely used without any fear of toxic manifestations.

Following a preliminary trial of zinc peroxide as a rectal packing, we were so impressed with its numerous advantages that we have instituted its use in all our rectal operations, both local and abdominoperineal. There is notably an absence of redness, swelling, or other inflammatory reaction, and healthy granulations appear at an earlier period with this than with any other dressing that we have used.

The principal advantages of zinc peroxide packing are that it does not adhere to the raw surface, it is easy to remove, it does not become even slightly foul, it is bactericidal especially for the anaerobes, it is mildly astringent and hence helps to control oozing, it prevents false union not only by the presence of the packing itself, but subsequently by the deposit of solid particles of zinc peroxide over the raw surface. This causes it to look gray for 3 or 4 days, after which clean, bright red granulation tissue appears. Healing



seems to progress a little faster than with other types of packing. Even though vaseline gauze is placed over the packing, the zinc peroxide wick usually becomes hard but this does not appear to be a disadvantage.

Of the 430 ambulatory cases in which operation was done in the Vanderbilt Clinic, Presbyterian Hospital under prolonged anesthesia in oil (neothiol etc.) we are presenting 252 comparable cases, in which the 3 types of packing were used, and which were followed to 3 months beyond the healing time.

TABLE 1.—COMPARISON OF THREE TYPES OF PACKING IN 252 CASES

Type of packing	Fistulae and crypts		Fistulae	
	No. of cases	Healing time (days)	No. of cases	Healing time (days)
Iodoform	21	26.5	6	32.4
Plain	57	43	21	34.4
Zinc peroxide	32	40.9	29	39

It will be noted that the healing time is reduced in both groups of cases in which zinc peroxide packing was used. This reduction, however, is more marked in the operations for fistulae, in which the dissection was greater. Clinically we were even more impressed by the advantage which zinc peroxide packing possessed over other types. It is far superior to anything else we have used, particularly with reference to the ease with which it is removed and the lack of pain and oozing afterward.

Since the number of comparable cases in which zinc peroxide was used is rather small, the statistical evidence of shortened healing time is not conclusive, but it does suggest that zinc peroxide used as a postoperative dressing in anorectal surgery is one more detail in surgical technique which may be of importance in further reducing the time of wound healing and increasing the comfort of the patient.

#### TECHNIQUE

*Technique of application of zinc peroxide packing* in all cases of anorectal operations whether done under local, spinal, or general anesthesia is as follows:

The powder has been previously sterilized in a test tube, fitted with a cotton stopper. A sufficient quantity of this sterile zinc peroxide powder usually 2 to 3 tablespoonfuls, is placed in a small mixing basin. Sterile distilled water or normal saline is slowly poured into the powder accom-

panied by stirring, until a suspension is produced which is about the consistency of heavy cream (40 per cent). A piece of 1 inch plain packing, 12 to 18 inches long is soaked in this suspension and folded to a length of about 3 inches. With a plain forcep grasping the free end, the packing is inserted through the anal canal without wadding up the end to form a bulbous extremity. It is so placed that it covers the entire raw surface and prevents any false adhesion of these surfaces. The packing molds itself into the anal canal and fills any cavities or crevices, but does not produce any discomfort, even if it becomes dried out and hard. Vaseline gauze placed over the packing and entire anal region at the end of the operation tends to prevent drying, which may cause some hardening of the pack. Then plain gauze covered by adhesive straps to exert pressure and hold the dressing in place is applied.

#### POSTOPERATIVE CARE

All packing material is usually removed at the end of 24 hours and rarely is replaced even in the case of fistulae. It may be left in place for 4 or 5 days until granulations have formed—McIntosh states that he usually leaves the packing in as long as it will stay up to 4 or 5 days to minimize the activity of organisms which may come down from the rectum with the passing of gas or feces. Following the removal of the packing, hot sitz baths are instituted twice a day mineral oil, 36 ounce is administered twice a day and a cathartic is given on the night of the first postoperative day followed the next morning by an enema if necessary. The hospitalized patients are discharged on the 3d to 5th postoperative day usually on the 4th.

In abdominoperineal resections, the most satisfactory packing which we have used has been prepared by soaking a large abdominal laparotomy pad in suspension of zinc peroxide powder in normal saline in the consistency of heavy cream (4 per cent). This pad is placed so that it lines the entire raw surface of the true pelvic cavity below the new peritoneal floor. The space within the zinc peroxide pad is then filled loosely with plain or iodoform gauze which is partially removed on the 1st or 2nd postoperative day. By the 5th day all the packing including the zinc peroxide pad is removed without any pain or oozing, since the zinc peroxide pad does not adhere to the raw surfaces. A grayish white surface remains for 3 or 4 days, due to the mechanical deposit of zinc peroxide particles over the raw surfaces. In the course of 2 or 3 days more, this surface materially clears, healthy granulations appear and healing pro-

reabsorbs more rapidly than following other types of packing. One great advantage of zinc peroxide packing, in general, is that it may be kept in place for days without producing a bad

Even though statistically, in a small number of cases, the healing time is not significantly altered by the use of zinc peroxide packing, clinically its many advantages as a rectal dressing suggest its wide field of usefulness.

#### CONCLUSIONS

1. Zinc peroxide packing does not produce any localized or localized toxic manifestations.
2. Zinc peroxide packing is safe to use in all

types of anorectal wounds, both local and abdominal.

3. Zinc peroxide packing does not adhere to the raw surfaces, and hence is easy to remove and does not produce oozing on its removal.

4. Zinc peroxide packing is hemostatic and tends to reduce the postoperative capillary oozing.

5. False union of the raw surfaces is prevented by the deposit of solid particles of zinc peroxide.

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# BASAL BODY TEMPERATURE IN DISORDERS OF OVARIAN FUNCTION AND PREGNANCY

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**I**N 1904 van de Velde reported that the basal body temperature of women of childbearing age exhibited rises and falls in a regular cyclical manner corresponding to the menstrual cycle. In 1930 he wrote again on the subject. He confirmed his earlier work and concluded that the sudden rise of the basal body temperature not only indicated activity of the corpus luteum but was actually caused by its function. He observed the temperature changes of one woman throughout the entire duration of pregnancy. Immediately after the onset of pregnancy the exact date of which was known, the temperature rose rapidly and remained at a high level with no further cyclical fluctuations. During the last 3 months the temperature gradually fell and began to assume a form suggestive of the cyclical fluctuations of the nonpregnant state.

Upon examining the data presented in van de Velde's monograph, Harvey and Crockett (1932) were of the opinion that the author had demonstrated (1) under normal circumstances the cycle is regular in its wave-like fluctuations (2) with the menopause it ceases to appear the curve becomes irregular and lacks its former marked excursion (3) that under certain abnormal physiological conditions the cyclical fluctuations fail to appear but (4) that their reappearance can be artificially induced by ovarian tablet therapy (5) the ovarian cycle is presumably related to the menstrual cycle, but (6) menstruation is not a necessary concomitant of ovulation (or rather more precisely of the temperature cycle). These authors observed the morning oral temperatures of a 26 year old woman for 13 consecutive menstrual cycles and found that rhythmical wave-like fluctuations occurred coincidentally with the events of each cycle. They constructed a composite curve by fusing the observed temperatures for the 13 cycles and in this manner determined that the cyclical fluctuations were real as well as apparent.

Men, children, and women past the menopause do not exhibit cyclical fluctuations of the basal body temperature (Kleitman, 2, 3 and Zollmann-

Siebr 14). Zollmann-Siebr (1940) also observed that during pregnancy the basal temperature is strikingly constant and that during the amenorrhea associated with lactation, there are no cyclical variations. Just before the onset of the first menses after delivery however the temperature was found again to be biphasic in character. The same author made use of the temperature curves to determine the length of the postmenstrual and premenstrual phases. He observed that the duration of the premenstrual phase was relatively independent of the length of the menstrual cycle, whereas the postmenstrual phase varied directly with the length of the menstrual cycle.

Rubenstein and Lindsay (1937) demonstrated a statistically significant correlation between the fluctuations of the basal body temperatures and vaginal smears in 5 menstrual cycles observed in 43 young adult women without pelvic abnormality. Rubenstein (1937) observed a constant relation between the lowest body temperatures of the month and the characteristic ovulatory smear, and between the highest body temperatures and the characteristic premenstrual smear. He concluded that the temperature cycle was as trustworthy an indicator of ovarian function as the vaginal smear. Rubenstein (1939) made use of the basal body temperature curve for the detection of ovulation in the investigation of sterility. Zuck (1938) in reporting basal body temperature studies for the detection of ovulation published the temperature curves recorded during the last menstrual cycle and onset of pregnancy in 20 women. He observed that the temperature during pregnancy remained high as in the last part of the menstrual cycle and that the temperature could be used as a sign of pregnancy before other methods of diagnosis were possible. He reported the observation that ovulation as well as menstruation may occur after conception begins. His diagnosis of early pregnancy in the case in point was apparently made on the basis of breast tenderness and subsequent delivery date of fetus—since the basal body temperature curve in the patient observed fluctuated normally for a complete cycle after the diagnosis of pregnancy was made.

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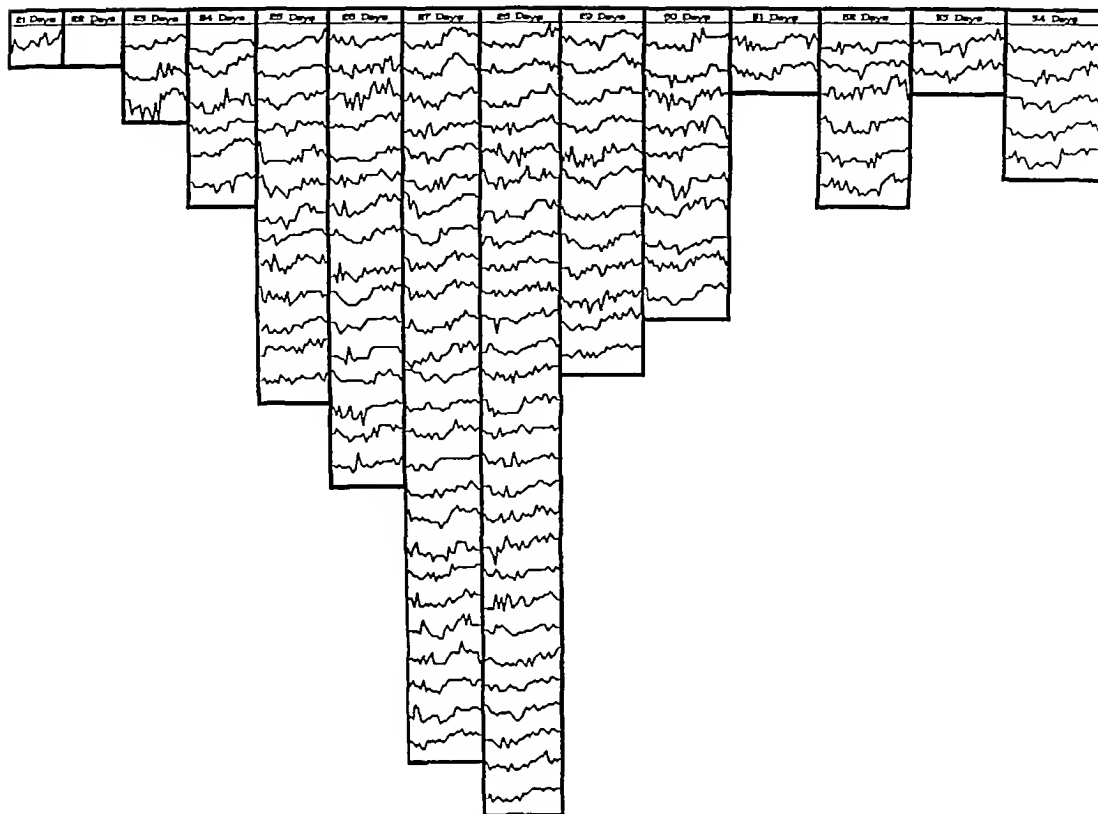


Fig. 1 Basal body temperatures recorded by 35 women during 130 normal menstrual cycles. Note biphasic character of each curve. The temperature is relatively low during the first half of the cycle and relatively high during the second half. The "thermal shift" occurs at midintermenstruum.

Palmer, following the appearance of a paper by Mocquot and Moricard (1938) on the presence of glycogen in the endometrium as a test of action of progesterone, pointed out that in all cases in which biopsies of the endometrium were made before and after the "thermal shift" of the mid-intermenstrual portion of the basal body temperature curve of normally menstruating women, those performed before the shift showed no glycogen while those performed after the shift showed the presence of glycogen.

Palmer and Devillers (5) studied the basal body temperatures in 75 women with gynecological complaints. From their series of abnormal individuals they were not able definitely to fix the date of ovulation by the temperature changes alone. They did conclude, however, that the period of maximum fecundity corresponded with the time of minimal temperature. They associated symptoms of ovulation (pain, hemorrhage, leucorrhea, mastalgia, etc.) with this period in

the cycle. They were able to foretell quite accurately the date of subsequent menstruation in women with irregular menses and thereby avoided doing repeated endometrial biopsies in order to obtain a real premenstrual specimen. Palmer and Devillers (6) checked the thermal effects of sex hormones in women and observed that in ovariectomized women who ran a nonfluctuating basal body temperature curve the injection of 5 milligrams of estradiol benzoate produced a decrease in temperature lasting several days and that the injection of 10 milligrams of progesterone produced an increase in basal body temperature for 2 days. The injection of 10 milligrams testosterone propionate produced a transient drop in temperature.

Rubenstein (10) favored the combined use of basal body temperatures and vaginal smears as a technique for the study of functional sterility and claimed accuracy in detecting early pregnancy as great as with the use of the Friedman pregnancy

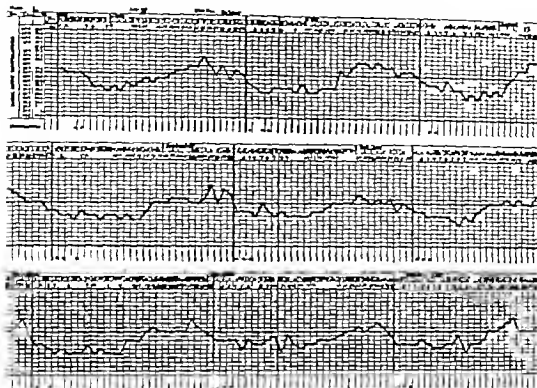


Fig. 1. Example of normally occurring menstrual cycles and normal basal body temperature curves during nine consecutive cycles. Note regularly occurring biphasic swing of temperature with fall associated with menstruation, "thermal shift" during the midintermenstruum and sustained rise during the second half of each cycle.

test. The diagnosis of early pregnancy by temperature curves in 8 patients unaware of the existence of pregnancy because of menstrual flow was confirmed by the recovery of fetal membranes.

Thus it has been established that the basal body temperature of regularly menstruating women fluctuates rhythmically and cyclically and that the rises and falls are actually brought about in some way by the activity of the two types of hormones (estrogens and progesterone) elaborated by the ovary. For the past 34 years we have made use of the basal body temperature in our gynecological endocrine clinic in cases of menstrual disorders and sterility. In Figure 1 are charted the individual basal body temperatures of 35 normally menstruating women recorded during 130 complete menstrual cycles. The curves have been grouped according to the length of the cycles. Although there are occasionally wide variations in an individual's temperature

record, every curve on the chart exhibits a biphasic tendency. During the estrin phase of ovarian activity the temperature is relatively low and during the progesterin phase it is relatively high. There is a fall in temperature associated with the onset of menstruation followed by a rise in temperature at approximately the midintermenstruum. The rising temperature section of the curve that normally occurs at midintermenstruum will subsequently be referred to as the thermal shift.

Figure 2 is a typical record of the basal body temperature of one individual recorded for 9 consecutive normal menstrual cycles. Wide variations in the temperature are not so numerous when the record is carefully kept for longer periods of time by the same individual. Emphasis must be laid on what constitutes a basal temperature record. The temperature should be taken at the same time each morning after a good night's rest. It should be taken by rectum immediately upon awakening and before the patient gets out

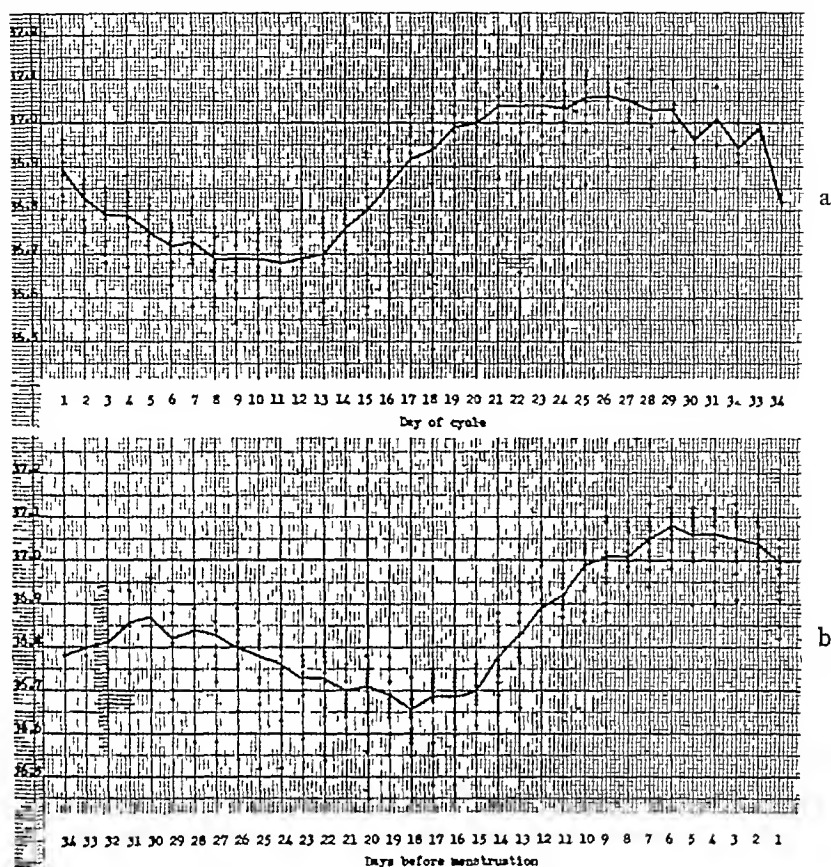


Fig 3 a Composite temperature curve constructed from all the temperatures recorded in Figure 1. The first day of each cycle coincides. Note the broad area covered on the graph by the rising temperature section of the curve. b, Same as a except that the last day of each cycle coincides. Note that the rising temperature section of the composite curve narrows down to a more uniform fitting of superimposed curves.

of bed. It is recommended that the thermometer be shaken down the night before to avoid the exertion accompanying this activity in the morning. Wide variations in the basal temperature have not been observed in patients who take their temperature according to instructions. Failure to comply with such instructions may be detected by the recording of abnormally high temperatures as well as extreme day to day variations.

The data were analyzed further by constructing a single composite curve for all the records in Figure 1 (Fig 3a). Separate composite curves for each group of cycles were first plotted so that the first day of each cycle coincided regardless of the length of the cycles. It was observed that the area on the graph comprised of the rising temperature sections of the curves was broad and

that good fitting of curves was not obtained by superimposing them in this manner. The separate composite curves were again plotted so that the last day of each cycle coincided regardless of the length of the cycles (Fig 3b). Lining up the curves in this manner is justified by the following observation—and serves to confirm the finding reported by others—that the progesterin phase of ovarian activity is relatively constant and independent of the length of the menstrual cycle. Note that the area on the graph covered by the rising temperature section of the curves becomes narrower and more uniform. There is good fitting of the composite curves when they are superimposed in this manner. The relative constancy in the length of the high temperature phase has been observed in longer menstrual cycles, 35–162 days, and confirmed by the finding

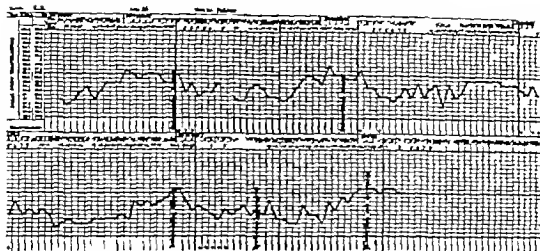


Fig. 4 Sterility in patient with bicornate uterus and constriction of the lower portion of the uterine canal. Details of endometrial histology are described in text.

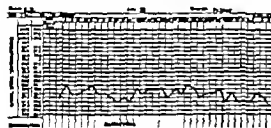


Fig. 5 Secondary amenorrhea due to persistent follicular activity. Note persistently low anovulatory type of basal body temperature.

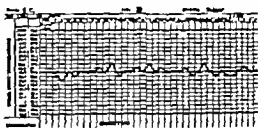


Fig. 6 Secondary amenorrhea of anterior pituitary origin. Note persistently normal basal body temperature without cyclical fluctuations.

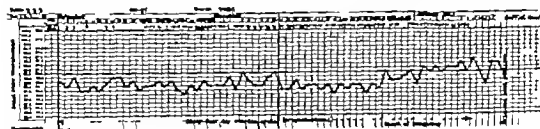


Fig. 7 Onset of pregnancy during prolonged intermenstrual interval in patient with bicornate uterus whose menses occurred irregularly every 6 months. The diagnosis of pregnancy as confirmed by positive Friedman test on the 20th day of pregnancy.

of progestin reactions in endometrial specimens obtained during the phase of elevated temperature and estrin reactions in specimens taken before the temperature began to rise. We have observed no real exceptions to the correlation between basal body temperature records and endometrial findings.

Figure 4 is the basal body temperature record of a sterile patient for 5 consecutive cycles. Endometrial specimens were taken on 3 occasions, as indicated in the figure, during the progestin phase. It was possible to sound this patient's uterus for depth of only 6 centimeters each time and, since each specimen of tissue showed estrin

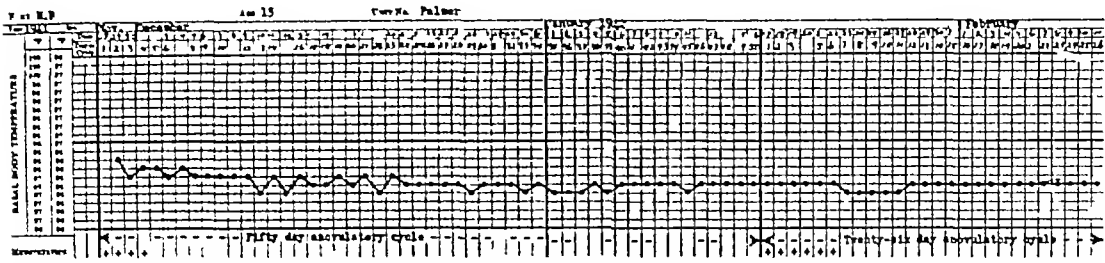


Fig 8 Menorrhagia of puberty, uterine bleeding was profuse and occurred irregularly. The endometrium was characteristically hyperplastic and showed no evidence of secretory activity. The basal body temperature was persistently low with complete absence of evidence of ovulation and corpus luteum function.

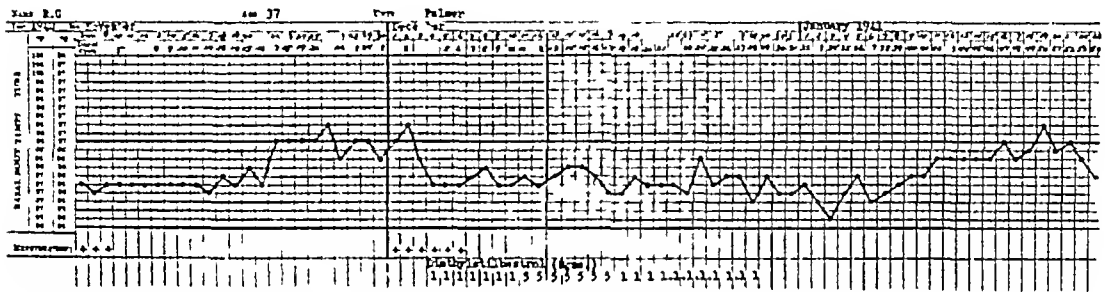


Fig 9 Inhibition of ovulation in a patient with regularly occurring menstrual cycles and normal basal body temperature curve. Diethylstilbestrol was administered as shown. A gradual withdrawal of estrogen may not be expected to be followed by bleeding. The estrogen administered resulted in a prolongation of the intermenstrual interval to 54 days, the cycle terminating with ovulation and corpus luteum formation.

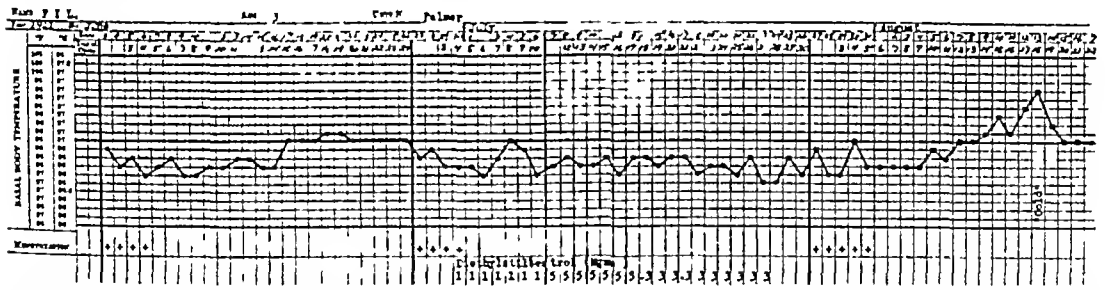


Fig 10 Inhibition of ovulation in a patient with regularly occurring menstrual cycles and normal basal body temperature curve. In this experiment diethylstilbestrol was administered as shown in the figure beginning the 4th day of the cycle. The bleeding that occurred on July 27 was estrogen withdrawal in type. The ovarian cycle beginning on June 27 and terminating in ovulation and corpus luteum function was 52 days in length.

activity only. It was suspected that the cavum uteri had not actually been entered. A hysterosalpingogram was obtained postmenstrually (Fig 13). A marked narrowing of the uterine canal at about 6 centimeters from the external cervical os and a bicornate uterus were observed in the x-ray film. Following the procedure during the next premenstrual phase the patient was anesthetized and her uterine canal dilated. The mid portion of the uterus could then be sounded to a depth of

8 centimeters and either uterine horn to 10 centimeters. A normal progestin phase endometrial specimen was obtained at this time. Thus the basal body temperature gave evidence of corpus luteum activity that was not apparent from specimens obtained from the lower portion of the uterine canal. Figure 5 is the persistently low basal body temperature record of a patient with a secondary amenorrhea of more than a year's duration,



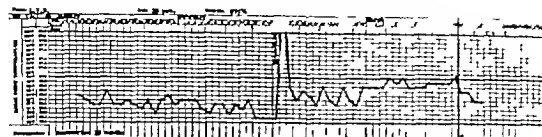


Fig. 1. Case of arrhenoblastoma: basal body temperature persistently low and irregular in type. Note that immediately following operation the basal body temperature became biphasic in type indicating cyclical ovarian activity. First menstruation occurred 23 days after operation.

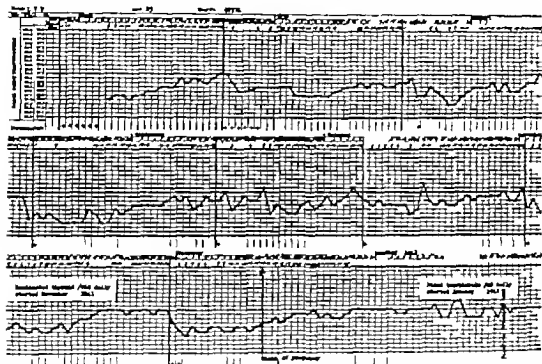


Fig. 2. Basal body temperature and recurring menstrual cycles in a patient following the removal of an arrhenoblastoma. The temperature shows the normal biphasic type of curve characteristic of normal ovarian activity. Note 3 day cycle from September 4 to October 6 (actual), probably anovulatory. Onset of pregnancy as suspected from the prolonged sustained temperature rise when patient as seen on January 8. Suspicion of pregnancy confirmed by positive Friedman test on January 21.

normal vaginal hydrogen-ion concentration (4.4) and fully developed secondary sexual characteristics. The diagnosis of amenorrhea due to persistent follicular activity was made on the basis of these observations and was confirmed by the finding of hyperplasia of the endometrium in the estrin phase.

Contrasted with the preceding case, Figure 6 is the basal body temperature record of a patient

with a secondary menorrhea of 6 years duration. The patient was thin with practically no development of breasts or other secondary female sexual characteristics. Her vaginal hydrogen-ion concentration was 6.6 and the vaginal membrane was atrophic. The higher temperature without cyclical fluctuations indicated absence of ovarian activity similar to the sort seen in menopausal women. The patient had never ex-

hibited menopausal symptoms, however, and accordingly the amenorrhea was attributed to primary pituitary rather than primary ovarian dysfunction

Figure 7 is a portion of the basal body temperature record of a patient with hirsutism, menstrual cycles that varied in length from  $1\frac{1}{2}$  to 6 months and sterility. The two cycles immediately preceding the progestational cycle shown in the figure were 162 days and 42 days in length, respectively. Each of these 2 prolonged cycles was characterized by a terminal sustained temperature rise of approximately 14 days. An endometrial specimen taken 22 days before the end of the 162 day cycle showed estrin activity, and a specimen taken 6 days before the end of the 42 day cycle showed progestin activity. The patient was instructed to observe her temperature record for evidence of her fertile period, as characterized by the thermal shift, at which time she should have intercourse on each of 3 or 4 consecutive days. Her temperature varied so irregularly that this effort was made several times. However, not until the advent of a sustained rise that occurred after December 27 did any signs or symptoms of pregnancy occur. The date of onset of pregnancy was arbitrarily set at December 27 and will be checked subsequently by dates of quickening and delivery. The diagnosis of pregnancy was confirmed by a positive Friedman test when, from the basal body temperature record, the menstrual period was 6 days overdue.

Figure 8 is the basal body temperature record of a patient of 15 years with menorrhagia of puberty. The irregularity of cycles, full female sexual development, persistently low temperature, and high vaginal acidity (pH of 4.4) led to the diagnosis of hyperplasia of endometrium in the estrin phase. The diagnosis was confirmed at the time of a dilatation and curettage by the finding of "Swiss cheese" hyperplasia of the endometrium.

Figure 9 is the basal body temperature record of a normally menstruating woman in whom ovulation and menstruation were delayed with diethylstilbestrol. The estrogen was administered as shown in the figure. A gradual withdrawal of estrogen was effected by first giving large daily doses of the drug for 2 weeks followed by a sub-threshold dose of 0.1 milligram daily for 10 days. Thus a complete ovarian cycle of 54 days uninterrupted by estrogen withdrawal bleeding was produced. The patient had never before had an intermenstrual interval of longer than 30 days.

Figure 10 is the basal body temperature record of another normally menstruating woman in

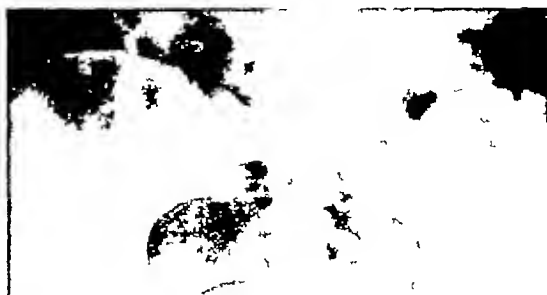


Fig. 13 Hysterosalpingogram of patient whose temperature is shown in Figure 4. Note bicornate uterus and constriction of uterine canal at a point approximately 6 centimeters from external cervical os.

whom ovulation but not uterine bleeding was delayed with diethylstilbestrol. Contrasted to the previous case, a more abrupt withdrawal of estrogen was effected by using a larger daily dose of estrogen after the proliferative phase. A complete ovarian cycle of 52 days was thus produced interrupted by a phase of estrogen withdrawal bleeding after the 30th day of the cycle. The patient was not aware of any abnormality of ovarian function but merely felt that she had experienced two menstrual periods at intervals of 30 and 22 days, respectively. From the temperature record, however, it must be concluded that the bleeding that occurred after the 30th day was anovulatory, that ovulation was temporarily inhibited, and that a complete ovarian cycle of 52 days was produced.

Figure 11 is the basal body temperature record of a patient with amenorrhea of 15 months' duration due to the presence of an arrhenoblastoma. The temperature record for the last month prior to the removal of her tumor was persistently low and anovulatory in type. Immediately following the removal of the tumor the temperature became biphasic indicating resumption of cyclical ovarian activity. The endometrium was examined on two occasions before operation and was found to be atrophic. Figure 12 is a continuation of the same patient's temperature record through 7 successive menstrual cycles and the onset of pregnancy. The biphasic character of the curves persisted except in the short 23 day cycle beginning September 14. This was probably an anovulatory cycle but was not confirmed by examination of the premenstrual endometrium.

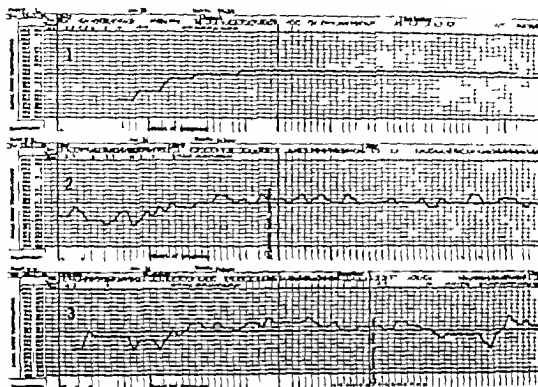


FIG. 14. The onset of pregnancy in 6 patients revealed by the basal body temperature curve. (1) F. L. L., case of sterility: onset of pregnancy occurred following total fertilization on July 3. (2) M. B., case of sterility: pregnancy suspected from basal body temperature curve and confirmed by positive Friedman test, first postmenstrual period, 11 days overdue. (3) M. P., case of sterility: onset of pregnancy suspected from basal body temperature curve. A spontaneous abortion occurred with subsequent fall and resumption of biphasic tendency of temperature curve. (4) L. A. B., case of sterility, treated by the removal of an embryo-ectopic, onset of pregnancy suspected from basal body temperature curve and confirmed by positive Friedman test on January 1. (5) E. K. A., case of habitual abortion: onset of pregnancy

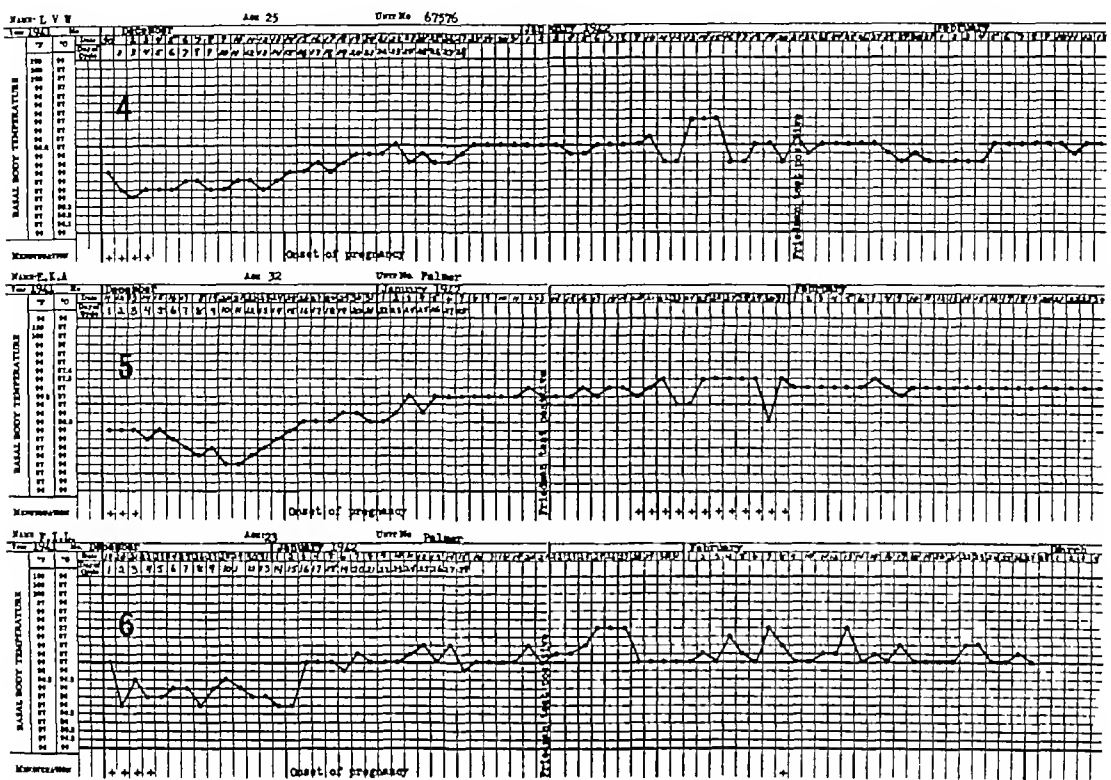
Premenstrual endometrial specimens were taken however on June 18 and again November and were found to exhibit normal progesterin reactions.

Figure 14 is comprised of the temperature records of 6 normally menstruating women through the onset of pregnancy. The date of onset of pregnancy has been arbitrarily recorded as the 15th day of the menstrual cycle during which the pregnancy occurred. In 3 of the patients (Nos. 2, 5, and 6) the diagnosis of pregnancy was confirmed by positive Friedman tests before the first missed menstrual period was a week overdue. In a fourth patient (No. 4) the Friedman test was positive when the first missed menstrual period was 3½ weeks overdue. Pregnancy tests were not done in the 3 remaining patients, one of which (No. 3) aborted spontaneously at the 5th week of pregnancy. Her temperature record reveals the resumption of cyclical ovarian ac-

tivity following the spontaneous abortion. Patient No. 5 threatened to abort and had uterine cramps and profuse bleeding for 12 days, but she was a week pregnant. Her temperature remained elevated, however, and she did not abort until she experienced a recurrence of the symptoms of threatened abortion, month later. Just before the end of the 4 week interval between the first and second threat a positive Friedman test was obtained. This positive reaction regarded as evidence that the first threat of abortion had passed and that the pregnancy has remained intact. The same information was obtainable from the sustained high level of the basal body temperature.

#### SUMMARY AND CONCLUSIONS

The subject of basal body temperature as it is affected by cyclical ovarian function has been



suspected from basal body temperature curve and confirmed by positive Friedman test when menstrual period was 6 days overdue. A threat occurred as shown in the figure, associated with profuse bleeding and cramps, January 20 to 31, inclusive. Abortion did not occur at this time, however, it did occur subsequently on February 25 followed by a return of the cyclical biphasic character of the basal body temperature curve. (6) F I L, case of sterility, onset of pregnancy suspected from basal body temperature and confirmed by a positive Friedman test when menstrual period was 6 days overdue. A threat occurred on February 7 associated with cramps and 1 day of bleeding following which pregnancy progressed normally.

briefly reviewed. The cyclical wave-like fluctuations in the basal body temperature of normally menstruating women are in some way due to the activity of the estrogens and progestogens elaborated by the ovaries. The progesterin phase of normal ovarian activity is relatively constant and averages 14 days in length regardless of the length of the menstrual cycle. The irregularity in the length of normal and abnormal menstrual cycles is attributed to irregularities in the duration of the estrin phase of ovarian activity. No exceptions to the correlation between the two phases of basal body temperature and their respective phases of estrin and progesterin endometrial activity have been observed. Information that is extremely helpful in the diagnosis of amenorrhea and menorrhagia has been obtained from basal body temperature records.

The inhibition of ovulation and menstruation by the use of an estrogen has been demonstrated and analyzed by the basal body temperature record. Sterility apparently due to improper timing of coitus may be overcome if use is made of the basal body temperature record. The basal body temperature record of a patient before and after the removal of an arrhenoblastoma and during the onset of pregnancy has been recorded. The diagnosis of pregnancy may be made from a patient's basal body temperature as early, if not earlier, than can be made from other signs, symptoms, or tests. The basal body temperature method of investigating ovarian function is advocated as a procedure within the reach of any intelligent patient equally as reliable in a qualitative way and far

less costly than estrogen androgen gonadotropin, and pregnandiol determinations, vaginal smears, vaginal hydrogen-ion concentration and vaginal and endometrial biopsies.

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# A TECHNIQUE OF SKIN GRAFTING

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**B**ECAUSE of the large number of burns and the resulting scar contractions and deformities which will occur during the coming years of worldwide conflagration, any procedure promising a simplification of, or an improvement in, the technique of skin grafting should be a timely contribution

There are several ways of transplanting free skin. Fundamentally there is but one requirement to get "takes" in the application of autografts, this is that the graft be supplied with adequate nutrition before its cellular elements undergo death. As pointed out by Davis and Traut, an active degenerative process begins in the graft immediately after it is cut and continues until complete death of the excised tissue or until regenerative processes have supervened and the transplanted tissue has become established in its new site. To receive adequate nutrition, early vascularization of the transplant must be realized.

Those factors which mitigate against early vascularization may be listed as (1) an anatomically poor recipient bed, (2) faulty approximation of

graft and recipient surface, (3) an improperly prepared graft, and (4) the presence of infection.

By an anatomically poor or unsuitable recipient bed is meant an area which does not have sufficient blood supply whether due to deep fibrosis or to its being covered by necrotic tissue and slough. Another cause of an unsuitable bed is a granulating surface which gives rise to excessive exudates. This complication is frequently due to foreign bodies, such as threads from gauze dressings, embedded in the granulations. Such a surface will not permanently support a graft. In such a case the granulations should be shaved off so as to remove the underlying foreign material. The presence or absence of such foreign material in the granulating beds might well have given rise to the two schools of thought, one strongly advocating the removal of granulations before applying a graft, and the other just as vigorously condemning the practice. If there is no foreign material buried in otherwise healthy granulations, properly prepared and applied grafts will grow. All avascular scar tissue must be excised before grafting. The judicious use of the sulfonamides has largely eliminated the danger of septicemia following

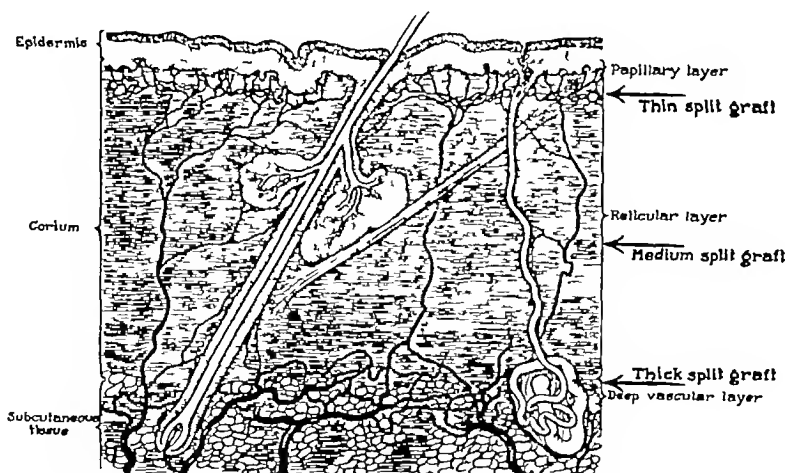


Fig 1 A schematic drawing of the skin to depict the nature of the blood supply, the rich anastomoses in the deeper portions of the true skin and the perpendicular branches extending from the anastomosing network through the more superficial corium. The indicated depths at which split skin grafts are cut explain why such success is encountered when these grafts are used, because of the many blood vessels cut across and ready to receive the vascular buds of the host's recipient bed.

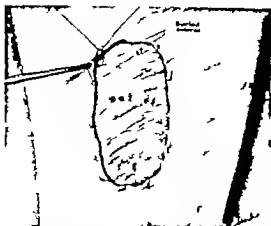


Fig. 2 If the skin is not attached firmly to the edge of the defect, it is carefully tacked in place with buried sutures. This procedure serves to stabilize the skin, prevent slippage of the graft, and reduce the size of the defect.

the exsiccation of tissue harboring pathogenic organisms.



Fig. 3 The defect is covered first with sheet of cellophane next to the wound, over this is placed sheet of perforated cellophane and the defect marked out with dye stained applicator. The nonperforated sheet of cellophane is discarded and serves merely to protect the wound from discoloration by the marking dye. The outline of the defect on the perforated cellophane is transferred to the back of an enamel pan.

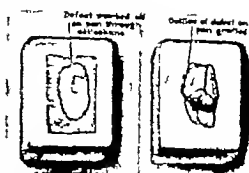


Fig. 4 a. The outline of the defect on the perforated cellophane is transferred to the back of an enamel pan by tracing over the outline with dye stained applicator. After removal of the sheet of perforated cellophane the excess of dye is removed to leave faint outline of the defect and insufficient dye to stain the graft when it is applied to the surface of the pan. b. The outline of the defect on the pan is covered with graft by the use of an enamel pan of skin as necessary to cover the outlined area with slight overlapping. The graft is placed with cut surfaces next to pan. Each piece of skin overlaps its neighbor slightly.

Faulty approximation of graft and recipient surface may result from numerous causes. Poorly applied dressings which fail to apply sufficient pressure and allow slippage of the graft do not favor vascularization. The collection of air, serum, blood, and purulent exudates under a poorly drained graft will cause it to become elevated and prevent the ingrowth of vascular buds.

Meticulous care should always be exercised to obtain the best possible graft for desired purpose. The use of the thin graft originally described by Thiersch is seldom indicated. The split graft includes corium or true skin and is the best form of free skin graft. For all practical purposes it can be cut in three thicknesses—thin, medium, and thick. When the skin is split through different levels of the corium, the numerous perpendicular vessels in the corium are cut across and present an ideal surface for early vascularization. A thick split graft can be so cut that it will include practically the full thickness of the skin and will serve essentially the same functions as the usual full thickness graft with the advantage that grafts of large area take readily. The deep layers of the dermis are rich in blood vessels forming an extensive anastomotic network. A full thickness or Wolfe Krause graft should always be cut with sharp knife and should be free of subcutaneous fascia and fat. It should never be trimmed away with scissors; the blades crush the tissues and traumatize the blood vessels in the corium.

The presence of virulent organisms, especially the hemolytic streptococcus and pyocyanus, will

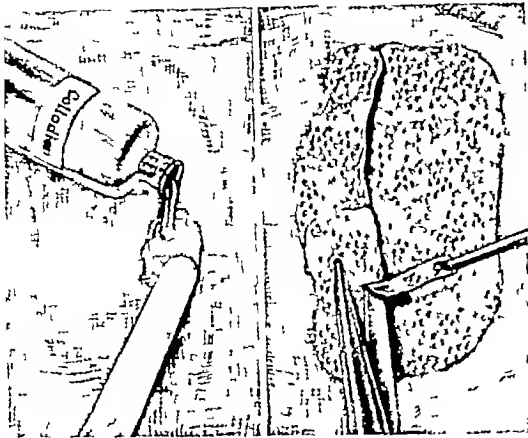


Fig 5 a, A single layer of gauze has been stretched over the back of the pan to cover the grafted outline of the defect. The gauze is attached to the graft with collodion. The collodion can be spread over the entire graft or merely placed around the outer edge of the graft and along the lines where the various pieces of skin overlap. b, After the collodion has been allowed to dry, the gauze and the attached graft are removed from the back of the pan. The overlapping skin is picked up and trimmed away to prevent rolling of any unattached edges of graft.

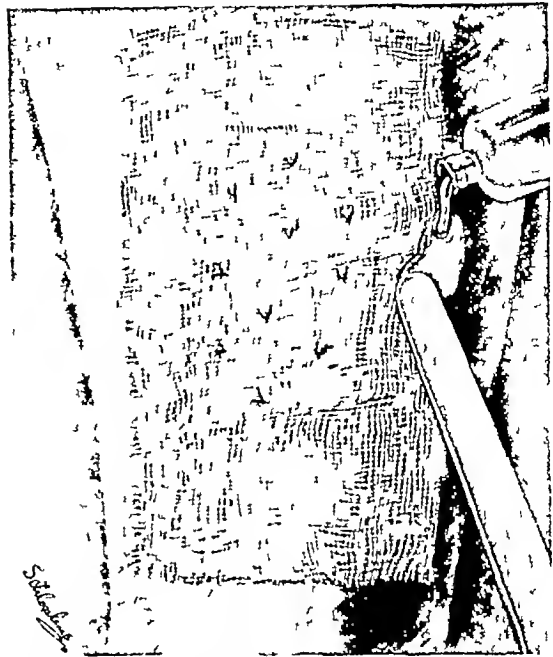


Fig 6 The graft attached to the gauze is transferred to the recipient, fitted to cover the defect, and held in place by attaching the excess gauze to the recipient's skin surrounding the defect. The graft is "pie-crusted" with small incisions to establish adequate drainage. Ordinarily no sutures are used to attach central portion of graft to defect.

defeat the object of the operation not only because of the direct action of the organisms on the cells of the grafts and because of the accumulation of excessive exudates between the surfaces, but also by causing the formation of thrombi in the small blood vessels bridging between the recipient bed and the vascular spaces in the graft. This process both inhibits the ingrowth of new vessels and interrupts the circulation in newly established channels. In each instance the result is delayed vascularization of the parasitic graft, which fails to survive because of inadequate nutrition.

#### THE MECHANISM OF A "TAKE"

This technique is suitable for any type of free graft, be it Ollier-Thiersch, split, full thickness, or deep pinch graft. The split graft, however, is the most satisfactory and has an optimal chance for a "take." A properly prepared split graft should cut transversely across the blood vessels in the corium (Fig 1). It is a common observation that with deep pinch grafts the first substantial evidence of a take is cyanosis at the center of the graft. When partial necrosis and death of a deep pinch graft occur, the thin tapered periphery is the vulnerable portion of the graft.

If a thick split graft is cut into pieces 1 or 2 centimeters square, as in the so called flagstone graft, these individual pieces will not have tapered edges. When these grafts "take," the following

sequence of events occurs. The fresh graft will be blanched and appear "dead white." After approximately 24 hours one can frequently see slender, bright red blood vessels tracing an irregular pattern across the entire surface of the graft. Furthermore, bleeding from the edge of the graft occurs frequently. Within next 12 to 24 hours the graft up to its very edge will have become cyanotic. This cyanosis is not limited to the center as in deep pinch grafts with thin tapered edges. During the following 3 to 7 days this cyanosis begins to disappear in a patchy, blotchy manner.

As illustrated in Figure 1, it is seen that a split graft cuts transversely across the blood vessels in the corium. When these grafts are applied to a donor area the first step in revascularization occurs by the growth of vascular beds into the perpendicular vessels of the graft. As stated previously, the small bright red vessels seen on the surface of the split graft at the end of approximately 24 hours result from the ingrowth of an occasional vascular bud and the wandering in of a limited number of red blood cells. The vessels appear red in color rather than cyanotic because the hemoglobin concentration in the vascular spaces is too



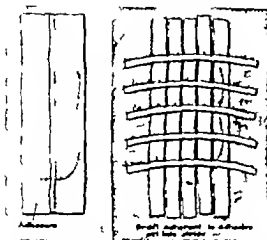


Fig. 7. a, Instead of covering the graft on the back of the pan with gauze and collagen as indicated in Figure 5, it is covered with sterile adhesive, removed from the pan, and cut into strips approximately centimeter wide. These strips should be cut like the scissors, because the blades will press the cut edges of adherent and graft firmly together. b, The graft bearing adhesive strips are applied to the recipient area by overlap of adhesive onto the adjoining normal skin of the recipient. A space of or sufficient between each strip allow for adequate drainage. Side-to-side slipping of the strips is prevented by cross stitching with narrow bands of adhesive.

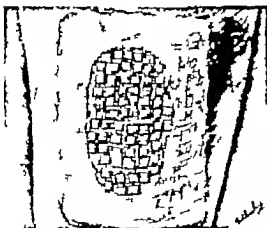


Fig. 8. To illustrate the technique of the so-called flap skin graft. A split skin graft of the desired thickness is placed cut surface down on the back of an enamel pan, covered with single layer of gauze and collagen as indicated in Figures 4 and 5. The gauze-faced graft is removed from the pan and cut into the desired size. Frequently these pieces of graft may be centimeters wide and several centimeters long. These individual grafts are applied to the recipient surface in much the same manner as pinch grafts. They may or may not be covered with second layer of gauze as shown in this drawing.

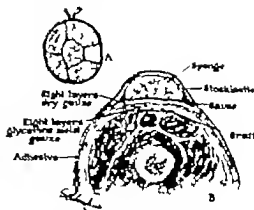


Fig. 9. The inset, (a) represents a bundle of several small sea sponges covered by a single layer of gauze to give the effect of a single sponge of sufficient size to cover large area. A fairly coarse grade of sponge moistened with 5 per cent glycerine an ester will exert pressure of approximately 30 centimeters of water and exert pressure of approximately 3 centimeters thickness. This amount of pressure appears optimal for maintaining good approximation and preventing the development of edema in the graft. (b) demonstrates the routine dressing used on free skin grafts. The surface of the graft may be dusted with minimal quantity of sulfathiazole followed by a layer of 4 thicknesses of gauze moistened with sterile glycerine. The gauze is cut to correspond to the outline of the grafted area and is applied one thickness at a time so as to obtain a smooth surface. This application is followed by 8 thicknesses of dry gauze. The sea sponge treated with 5 per cent aqueous glycerine solution, is placed over this dressing to depth of centimeters and is held in place by circular bandage or stockinette applied with sufficient tension to compress the sponge layer to half its original thickness. The entire dressing is further immobilized by being completely encased in adhesive and the part is placed at complete physiological rest, insofar as possible. This dressing should be removed ordinarily on the fifth day.

low it give the characteristic bluish color of anoxemia. As the process of revascularization proceeds and vascular beds have grown into more vessels, both arteries and veins, the concentration of hemoglobin increases to the point where cyanosis becomes evident. Anoxemia is present because as yet no venous drainage has been established. In the course of the next 3 to 7 days venous drainage is gradually established in various areas, resulting in a mottled clearing until finally venous drainage is established throughout the area of the graft. This sequence occurs throughout the entire surface of a split graft whereas only the center of a deep pinch graft with its tapered vascular peripheral zone is anatomically suitable to respond to this even revascularization. Also, when partial necrosis of a deep pinch graft occurs, the tapered avascular peripheral zone is affected.

Furthermore, it has been observed that a small split graft will "take" on subnormal soil while a small adjoining Ollier-Thiersch graft will fail

Davis and Traut demonstrated direct anastomoses between the host blood vessels and the blood vessels in full thickness skin grafts after 22 hours Reichert (6, 7) demonstrated that the regeneration of small arteries across clean operative wounds had occurred by the end of the 2nd day, that veins and lymphatics had become anastomosed by the end of the 4th and the beginning of the 5th day, and that the process was physiologically complete by the 8th postoperative day These facts coincide very nicely with observations made on autografts of skin, the appearance of occasional small, bright red blood vessels at about 24 hours, cyanosis in about 48 hours, and a mottled clearing of the cyanosis in 4 to 8 days

Davis and Traut believed that a graft was nourished first by the plasmatic circulation of Goldman, second, by direct anastomosis between the vessels in the graft and those of the grafted area, third, by the growth of capillaries of the grafted area into and along the degenerated vessels of the graft, and fourth, by the capillary upgrowth from the grafted area penetrating the connective tissue of the graft

Surgeons of apparently equal skill disagree as to the maximum size of a full thickness graft which will survive Many contend that there is an upper limit to size of full thickness grafts which will survive, a lesser number say that there is no upper limit All agree that "takes" do not occur as frequently as with split grafts of equal area The discrepancy of opinion here hinges on the preparation of the graft The true full thickness graft includes the entire thickness of the corium If any subcutaneous tissue is left on the raw surface and if the corium is not incised except at the periphery, very few blood vessels will be cut across because a relatively small number of vessels pass from the subcutaneous tissue to the skin However, if all the subcutaneous tissue is removed with sharp knife dissection, multiple small incisions will be made in the corium, and small areas of the deeper layer of corium will be excised and numerous small vessels in the true skin will be opened to receive the vascular buds from the recipient surface Failure to remove all subcutaneous tissue explains why the center of small full thickness grafts is lost when the periphery takes As emphasized by Garlock, a full thickness graft should be free of fat, should show white, and should be stippled with tiny depressions caused by the retraction of the minute ligaments of Cooper

# TECHNIQUE OF APPLYING VARIOUS MODIFIED TYPES OF SPLIT SKIN GRAFTS

A thin, medium, or thick split skin graft is cut by the techniques described by Blair and Brown, Padgett, and the author If the proper thickness of a split skin graft is applied by one of the three following methods, this type of graft can be used in most all instances requiring free skin grafting

A clean, dry wound may be covered by a single large graft sewed in place or held in place with collodion as indicated in Figures 5 and 6 The fixation of a large graft with collodion has the advantage that it is more rapidly executed than sewing the graft in place Since collodion does not adapt itself well to fixing a graft to an irregular surface, a graft should be sutured to such a surface Sutures should be removed on the 5th day to avoid the development of small stitch abscesses

If the denuded surface is not considered sufficiently clean to accept a large graft, grafts in strips, backed with adhesive tape, may be applied In this technique the design of the defect is outlined on the bottom of a sterile enamel pan (Fig 4) This area is covered with graft, raw side down The graft is now covered with sterile adhesive which extends 2 or 3 inches beyond the graft The adhesive and the affixed graft are cut with scissors into strips 1 inch wide (Fig 7) The blades of the scissors press the cut edges of graft and adhesive firmly together The skin edge is flush with the edge of the adhesive and there is no tendency for the edges to roll These strips are applied to the recipient area with 2 to 3 millimeters' clearance between them The ends of each strip are fixed to normal skin To prevent their lateral displacement, the strips are held together with 1/4 inch adhesive strips at 3 centimeter intervals, at right angles and extending onto normal skin at edge of defect This arrangement will not slip, the graft edges will not roll, and good drainage is provided Thus moderately dirty surfaces can be grafted early with serviceable skin

The immediate dressing is applied as follows Eight thicknesses of ordinary gauze are moistened with sterile glycerine and over this a sufficient number of layers of dry gauze are applied to give an even bed Sea sponge pressure is applied Daily thereafter the dressing is carefully removed and the surface inspected for possible accumulations of fluid under the strips by pressing on the adhesive with a curved clamp and milking the surface toward the intervals between the strips Such accumulations, although rarely encountered, are readily recognized and expressed After the first day the dressing is altered somewhat Four layers of gauze saturated with glycerine are ap

plied directly over the adhesive strips and covered with cellophane to retain the moisture. Over this dressing gauze is applied one thickness at a time until a sufficiently thick layer has been applied to give an even moderate pressure. Ordinarily this dressing is changed daily. In a week the entire surface including the narrow intervals between the strips will be epithelialized. The adhesive strips can be separated from the underlying grafts at any time. After 5 days a graft is usually quite firmly fixed to the recipient surface and little difficulty is experienced in removing the adhesive. In fact the adhesive plaster has become so completely separated from the graft that the thin epidermal layer which is shed from free skin grafts will remain loosely attached to the graft when the adhesive is removed.

In grafting clean, fresh wounds the strips may be applied without an intervening space. Such an area heals smoothly and the final visual strips of graft are not conspicuous.

In instances in which pinch grafts are indicated a split skin graft can be cut, backed with adhesive tape or gauze and collodion (Figs. 5 and 7) to prevent curling of the skin, and cut into pieces of the required size. These portions of skin designated as "flagstone grafts" (Fig. 8) are applied directly to the donor surface. These grafts may be placed close together to give a permanent and serviceable skin or they may be cut into very small pieces and placed at much wider intervals to act as centers of epithelialization; this latter procedure serves to provide temporary covering of thin epithelium as is occasionally required in extensive burns when sufficient skin is not immediately available to cover the large granulating surfaces. The after care is the same as for pinch grafts.

#### GLYCERINE AS A DRESSING MATERIAL FOR FREE SKIN GRAFTS

Sterile glycerine makes an excellent dressing for all types of free skin grafts since the hygroscopic properties of glycerine prevent maceration of the graft, and since it inhibits the growth of bacteria and prevents the accumulation of fluid under the graft. Pure glycerine can be used directly on the skin for long periods without evidence of irritation. When glycerine was first considered as a dressing for free skin grafts, it was expected that 100 per cent glycerine would be too desiccating but it was found to be entirely satisfactory.

The following technique is employed when dressing grafts applied to clean areas. A layer of about 8 thicknesses of ordinary surgical gauze

moistened with glycerine is applied directly to the graft. This gauze is covered with a layer of an additional, equal quantity of dry surgical gauze over which sea sponges are applied to give a moderate uniform pressure. The whole is held in place with massive dressings and immobilized by the liberal use of adhesive tape (Fig. 9). The dressing should be changed as often as indicated if infection is present. By the use of this dressing material successful free grafting can be performed under circumstances in which failure ordinarily results.

#### SEA SPONGE PRESSURE

The economical, light colored, household sea sponge applied over a graft gives the moderate pressure required to keep the graft in close apposition with the recipient bed without interfering with the circulation only so long as the sponge is moist. In ordinary practice the sponge is moistened with physiologically normal sodium chloride. This sponge soon becomes dry and hard and no longer acts to give the desired pressure. If the sponge is moistened with a 25 per cent glycerine solution, however, it will retain its resilience and exert uniform moderate pressure indefinitely (Fig. 9). If a 25 per cent aqueous glycerine solution is not available, the commercial 4 T 37 solution (beryl-resorcinol) may be used, because this solution contains approximately 25 per cent of glycerine. Sponges treated in this manner are useful whenever prolonged uniform sponge pressure is desired.

#### SUMMARY

1. The mechanism of takes of free skin grafts is discussed.

A new technique for fixing large split grafts to the recipient bed is suggested.

3. A method of applying grafts in strips faced with adhesive tape is presented.

4. The flagstone graft is described.

5. The use of glycerine as a dressing for grafts is given.

6. A treatment of the ordinary sea sponge to ensure uniform moderate pressure is described.

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# ESSENTIAL POINTS IN THE OPERATIVE TECHNIQUE OF GASTRECTOMY

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**G**ASTRECTOMY is rapidly becoming the most widely employed operation for ulcers of the stomach and duodenum and is definitely pre-eminent in the treatment of operable cancers. Certainly, no one will deny that gastrectomy, whether partial or total, is the greatest favor which the surgeon can confer upon an individual, who, otherwise quite healthy, suffers from carcinoma of the stomach.

Unfortunately, far too many patients arrive at our hospitals with malignant gastric growths that are too extensive to be benefited even by total gastrectomy. All too often, this fatal tardiness, this ghastly delay, is caused by fear of the surgeon's knife. Yet this is the one humane instrument, which, if it cannot always cure, can at least palliate.

In a sense, we surgeons have been in part responsible for this fatal procrastination. The mortality rate after gastric resection, particularly total gastrectomy necessitated by cancer, has been far too high. Too many people, of their own knowledge, are aware of deaths at or soon following operations for cancer of the stomach.

Of course, we cannot force people to take periodic medical examinations to the end that the cancers will be caught in their early stages, but we can, at least, take advantage of every diagnostic aid at our disposal to help us segregate the operable from the inoperable cases.

The situation is perhaps not so bad in the case of gastrectomies to remove gastric or duodenal ulcers. Such patients, unrelieved of the symptoms by other therapeutic measures, not only are more amenable to the idea of undergoing surgery but also do not view an ulcer operation with the fear they hold for a cancer operation. Moreover, we know now, and the consensus will bear me out, that subtotal gastrectomy is the operation of choice for gastric ulcers, other methods having failed to give comparable complete relief or prevent recurrence of ulceration (Abell). Nonetheless, even with the advantages of this procedure and the good results obtained, there are those who have hesitated to employ it for reasons other than the difficulties of the technique.

Undoubtedly, the chief deterrent to gastrectomy has been the high mortality rate when this

type of surgery has been undertaken by general surgeons who have had infrequent opportunities to perform such operations. Until very recently, the same could be said even of the work done by so called "stomach surgeons."

In my opinion, the dangers of this situation were quite clearly indicated by Lahey, who, in a discussion on subtotal gastric resection, stated "I have repeatedly said that there is no surgical procedure with which I have had anything to do which has been more difficult to standardize and in which it has been more difficult to bring the mortality rate down to within reasonable limits than that of subtotal gastrectomy. I think one of the things one should realize is that the price in mortality is too high in this operation for it to be done as hernial repairs or other more simple surgical procedures are done. It should be put in the hands of a limited number of men, and I do not mean just three or four in the country, but in communities someone should be given enough experience with this operation to become so expert with it that the mortality can be kept within reasonable limits within that community."

Only by experience, by constant improvements in technique, can the mortality of gastrectomy be lowered. Although improvements and skill have definitely tended to bring about a lower mortality ratio during recent years, the rate is still far too high.

Quite recently, Abell, in a review on gastrectomy, pointed out that, for the country at large, the death rate in subtotal gastrectomies approximates 8 or 10 per cent, proving that it is still a serious operation and one not to be undertaken too lightly. In the case of partial or subtotal gastrectomy for cancer of the stomach, he estimated the average mortality to be approximately 10 per cent. He believed that the ultimate results in operable groups compared favorably with those obtained in cancers situated elsewhere, when the criterion of operability is fairly considered.

The mortality in cases of total gastrectomy for carcinoma of the stomach is much higher. Abell estimates that the death rate in the reported cases has averaged 40 per cent. However, he believes that the difficulties of executing the total gastrectomy operation, its high mortality and the fact that life subsequent to it is relatively short com-

line to give this technique only a restricted place in the treatment of gastric cancer.

#### HOW SAFETY OF GASTRECTOMY HAS BEEN IMPROVED

As pointed out in a previous communication (2) it has been possible greatly to reduce the mortality rate in surgery for extensive cancer of the stomach by employing the two stage operation for gastric resection. With the two stage operation, patients of advanced age though feeble, have had an excellent chance of recovery and pulmonary complications have been absent. Doubtful cases are also benefited by this two stage procedure.

Constant effort has been made to improve the technique and yet to maintain the essential conservatism so necessary in gastric surgery. (3) With these improvements in technique, the mortality rate in our clinic has been lowered to the extent that gastrectomy is considered to be a comparatively safe operation.

Some of the danger areas in the operation will be discussed as well as improvements in technique devised to eliminate the dangers. A description of the technique including the special features of the operation as we have developed them follows.

Extensive discussion of the pre-operative preparation in these cases is unnecessary because this is now an established procedure which can be found described in many excellent communications. It is needless to point out that the operation is seldom one of emergency and that, when ever possible the patient should be confined to the hospital before the operation as long as is necessary not only to permit more thorough examination but also to build up strength, resist ance and a proper psychological attitude. If the patient is anemic, the blood values should be brought to as nearly normal as possible by the administration of iron and liver preparations. Vitamin levels, particularly of vitamins B, C and K, should also be maintained, and it may be necessary to give supplemental vitamin therapy.

The important point in the technique is that the stomach should be empty and clean before the operation. If obstruction is present, gastric suction and irrigation should be used for several days. Of course during this time it is necessary to give ample fluids by the intravenous or subcutaneous method. If obstruction is not complete liquids only are given for 24 hours before operation and nothing is given by mouth after 12:00 o'clock of the night preceding the operation.

The anesthetic to be used is a matter of choice that lies between the surgeon and his anesthetist. It might be stated however that the tide is turn-

ing away from the newer anesthetics and going back to gas-ether anesthesia. In my opinion this trend is all for the best, especially in general surgical procedures.

Spinal anesthesia, intravenous anesthesia, or rectal anesthesia, with preliminary basal anesthesia may at times place the patient in a very precarious position because of their inflexibility. Although we have access to all of these anesthetics and very efficient anesthetists at hand to administer them, we still prefer the flexibility of gas-ether anesthesia. In our hands at least, the results have been every bit as good as those obtained with other anesthetics.

At the onset of the operation itself we usually make a long right rectus incision about 15 inch outside the median line which extends well below the umbilicus. In some long bellied individuals we sometimes make a midline incision. Good exposure is a distinct advantage. After exposure we usually infiltrate the rectus muscles with a small amount of procaine which seems to give better relaxation. A self-retaining retractor is used.

Of course exploration should be made to determine the operability and to note the extent of metastasis (if carcinoma) the degree of involvement, adhesions, other pathological conditions present, and so on.

#### TECHNIQUE OF GASTRECTOMY

The omentum with the transverse colon is brought outside the abdominal cavity and laid upon a warm, moist sponge. The ligament of Treitz is located and the jejunum is gently clamped with a smooth sponge forceps so that it will be at hand when needed for anastomosis.

Dissection of the gastrosplenic omentum is started well up on the stomach. This is the *first dangerous area* in our technique. The division throughout the omentum must be made very slowly and carefully, so as not to open the transverse mesocolon or to jeopardize the middle colic artery. If this accidentally occurs, it would necessitate resection of the colon. The division is carried up to the desired point of resection on the greater curvature and then the gastrophrenic omentum is similarly divided on the lesser curvature.

The next step, and this is the *second point of importance* in this description, is the division of the gastric vessels. The vessels should be gently stripped from the stomach wall with closed hemostat for a distance of 1 inch before being divided. This allows of sufficient room to place the stomach clamps without the interference of the adjoining omentum and, after division of the stomach, permits of perfect coaptation of the

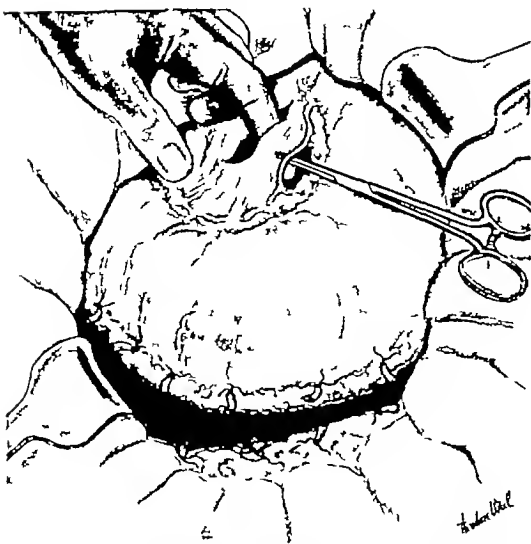


Fig 1 Stripping of blood vessels with closed hemostat, prior to division



Fig 2 Use of suction trocar in order to deflate the stomach

angles This last is very important to avoid leakage At this point, in order to cause a collapse of the stomach, it is well to insert a suction trocar into the stomach so as to remove any air or secretion present This is a *very important step*

Two large Payr's clamps are now applied to the stomach and the incision is made between the two clamps with a knife or cautery In applying the upper clamp, it is advisable to leave at least one-quarter of an inch between it and the tied artery previously mentioned

After division of the stomach, a warm moist sponge is placed over the proximal end The distal end is similarly covered and is held by the second assistant The remaining dissection of the gastroduodenal and gastrohepatic omentum is made from above down as previously described (3) This is the *third important step*

Removal of the area to be excised from above downward, beginning at the upper or proximal portion of the stomach, permits of visualization throughout the remainder of the operation This ability to visualize the entire operative field and even the area beyond it is a decided advantage, not only because one is less likely to injure the pancreas but also because there is less tendency to encounter troublesome hemorrhage in cases in which posterior adhesions have formed

A careful dissection is then continued as far down on the duodenum as desired However, one should be quite careful in stripping the pancreas from the duodenum This can usually be

done with a small moist swab, aided by occasional sharp dissection

Again, when tying the duodenal arteries, it is advisable that one-quarter of an inch should remain between the tie and the intended location of the small Payr's clamp to facilitate invagination It is also imperative to strip the duodenum clean so that the suturing will bring peritoneum to peritoneum This is the *fourth essential step*

The closure of the duodenum is a very important step, but if done correctly is very easily accomplished Two small Payr's clamps are applied, a quarter of an inch of clean duodenum being left below the distal clamp Again, division is made with a knife or cautery A linen Lembert suture is applied on the clamp and drawn tight as the clamp is removed Another Lembert suture is then applied over this and the stump is then covered with nearby omentum, which is sutured to the duodenum with two or three interrupted catgut sutures All clamps are then tied and removed and careful inspection is made to assure thorough hemostasis

The jejunum is brought up and held alongside the stomach with two Allis clamps It is raised to a position anterior to colon (anterior anastomosis)

This procedure is just as efficient as the posterior anastomosis and I believe its adoption has done more to lower the mortality of stomach resections than has any other step in our technique I am convinced of its worth, because I have used anterior anastomosis in all of my cases during the

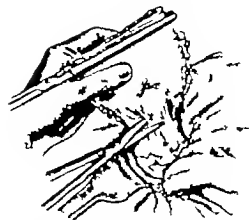


Fig. 3. Dissection of stomach from above downward division of posterior adhesions.

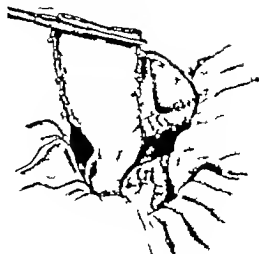


Fig. 4. Stomach held up ready for division of duodenum.

past 3 years. Previous to its adoption, I never felt satisfied with the posterior anastomosis. Certainly it was satisfactory in many cases especially when little of the stomach was removed. However with our present knowledge of the stomach secretions necessitating a high stomach resection in ulcer I believe the adoption of anterior anastomosis should be general. If it is generally accepted we shall see a marked drop in gastrectomy mortality all over the country.

A continuous Lembert suture is then applied to join the peritoneum of the stomach to the peritoneum of the jejunum below the Payr's clamp.

Two Alfs clamps are now applied to the stomach proximal to the clamps and the Payr's clamp is removed. As this is removed, a suction tube is inserted into the stomach, which is held together by the crushed tissues remaining after the clamp is removed. This is an added precaution to make sure that the stomach is empty. The necrotic material remaining after removal of the clamp is excised with a scissor and the stomach is held open and inspected. A continuous suture of No. catgut now closes the stomach and jejunum, care previously being taken to tie all bleeding vessels. This is *fifth important factor*. An interlocking suture, returning with a Connell suture is used. The linen Lembert suture is then brought back, completing the closure.

These sutures are easily applied if two details are borne in mind. First the peritoneum of the stomach must be stripped clean of all overlying tissue. Second, sufficient space must be left at the angles to permit of accurate closing as described.

The angles are now inspected and reinforced with several interrupted linen sutures. The distal jejunum is then stretched out and, with a few interrupted catgut sutures, is anchored to the ligament of the liver to prevent angulation.

This operation should not exceed 1½ hours. Speed, however, should not be permitted to interfere with accurate and painstaking surgery. There is usually no shock. In recent series of 5 cases of operation for ulcer no transfusions were needed. However materials for making immediate transfusions should always be available. If a good anesthetic has been given the patient will react before leaving the operating table.

#### POSTOPERATIVE CARE

An important part of postoperative care requires that nothing be given by mouth for 48 hours after surgery. A low Fowler position is advisable. Five per cent glucose in saline intravenously is started immediately. On the basis of our clinical observations, we feel that 2,000 cubic centimeters daily is sufficient. I am convinced that fluids in excess of this amount are sometimes harmful. Theoretically 4,000 to 5,000 cubic centimeters might be required, but certainly this much fluid is not clinically indicated in all cases. Of course this is a matter for individual judgment and many factors, such as age, debility, degree of dehydration, and the like should be taken into consideration before larger amount of fluids are given intravenously. However we are all coming to the conclusion that if patient

voids 1000 cubic centimeters daily, he is getting sufficient fluids

After 48 hours, water is given by mouth in small amounts. Seventy-two hours after operation the patient may be fed small quantities of tea and broth. It is most essential that care should be taken to avoid dilatation of the remainder of the stomach. If dilatation should occur, it must be relieved by the careful insertion of a Wangensteen tube. However, this complication has not appeared in our practice since we started doing the anterior anastomosis.

Lung complications should be guarded against, but it should be remembered that we have excellent allies to combat pneumonia in the form of the sulfonamide drugs. We have also found that a "self-helper" (a rod placed across the head of the patient's bed) is very useful. Encouraging the patient to pull himself up and take deep breaths does much to prevent hypostatic complications. I am convinced that removal of the stomach from above downward has done much to lessen postoperative pulmonary complications. Once this technique is mastered, it is surprising how few are the complications encountered.

However, in the case of patients who have undergone gastrectomy, the task of the surgeon does not end with the operation and the institution of adequate postoperative care. Depending upon the amount of stomach tissue removed, the surgeon should institute a regimen which the patient must follow if he is to enjoy and conserve his restored health. The amount and type of food and the frequency of ingestion should be clearly explained, physical restrictions, when necessary, should be imposed, and the importance of a healthy mental attitude should be stressed.

The recent studies reported by Ivy have an important bearing on this post-hospital regimen. His experimental studies indicated that, although in a strict sense the stomach is not an essential organ, its removal reduces the factor of safety and places a strain on the motor, digestive, and absorptive activities of the alimentary tube. "Proper nutritional care," he states, "is indispensable in maintaining health in animals without a stomach and very probably in men and women similarly handicapped." In Ivy's opinion, subtotal gastrectomy handicaps the patient only to the extent that it reduces the factor of safety in digestion and absorption. The extent to which acid is secreted after operation depends on the amount of acid-secreting mucosa removed and the degree of hypertrophy of the remaining portion.

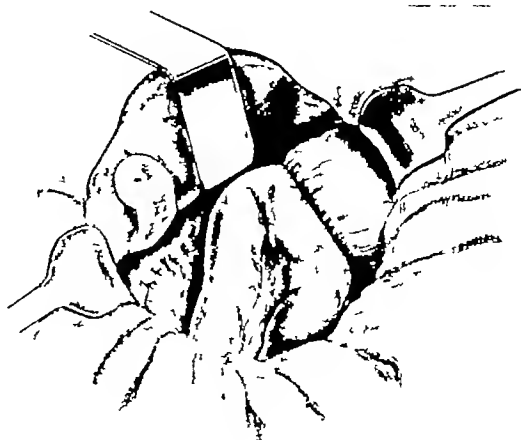


Fig 5 Finished operation Anterior—anterocolic—  
anastomosis

These rather encouraging findings do not, however, in any way eliminate the necessity for conservatism, skill, and good technique in gastrectomy. Rather, they stress the need for the institution of a specific nutritional regimen to meet the requirements of each patient individually.

#### SUMMARY

1 The mortality following gastrectomy, while reduced to some extent, is still too high when the average for the whole country is considered. This, we believe, is due to lack of experience and a failure to realize the several dangerous factors in the requisite technique.

2 We have presented the technique which in our hands has reduced mortality to the point where we consider gastrectomy a comparatively safe operation with remarkably few postoperative complications. We have attempted to stress the danger points of gastrectomies and have indicated means to avoid or overcome them. In our opinion the employment of anterior anastomosis is a major contributing factor in successful gastrectomy.

3 The importance of instituting a regimen for each individual patient who has undergone gastrectomy has been indicated.

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## HYPERMOTILITY OF THE UPPER LIP

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**W**E designate a certain deformity hypermotility of the upper lip because in repose the maxillary incisors and canines are not covered by the lip and in smiling or laughing the individual will expose not only the upper teeth but the alveolar ridge above the teeth (Figs. 1 and 2).

Hypermotility occurs in some individuals with short lips and is often associated with a hooked nose. In such a combination, overactivity of the elevator muscles of the lip rolls the lip upward and against the nostrils so that correction of the nasal hook alone does not improve the appearance of the patient because the lip deformity remains. Frequently there are also prominent and protruding upper teeth, a protrusion of the maxillary incisors and alveolar processes constituting a moderate degree of maxillary prognathism.

Hypermotility of the upper lip then is a very common abnormality. It creates an unpleasant impression, changing otherwise attractive individuals into decidedly homely ones. In spite of its prevalence, I have never heard any better advice given for its correction than the instructions to pull the lip downward and massage it as often as possible every day.

As I have indicated the chief factors in the deformity are a shortening and overactivity of the

muscles which elevate the upper lip. The etiological factors are obscure. The short lip is often a family characteristic. Whether of congenital postnatal, metabolic or functional origin, the position of the teeth and dental arches are determined by a myriad of forces acting upon them.

Our knowledge at the present time is inadequate to discuss prevention. Orthodontia should correct protrusion of the teeth and bad occlusion.

The operative procedure which we are advocating is a division of the muscles which elevate the upper lip. These are the levator labii superioris, the levator labii superioris alaeque nasi, the levator anguli oris, the zygomaticus minor and the vertical muscles between the upper lip and the nose.

The operative steps are best shown in Figures 3, 4, and 5.

Local anesthesia may be used but general anesthesia facilitates the procedure. The incision in the labiodental fold extends from canine to canine tooth and down to the bone from the surface of the maxilla. All tissues are separated with a perosteal separator beneath the nostrils up to the side of the nose as high as the infraorbital ridge and as far laterally as the zygoma. A right angle knife is inserted at the outer limits of these elevated tissues and, with its point turned toward the skin, the muscles are divided to and part way up the side of the nose; then it is curved around the side of the nose to beyond the midline, here it meets the incision from the other cheek. It must first be emphasized here that separation of the tissue from the surface of the maxilla and section of the muscles to right angles to the skin must be carefully performed. The necessity of this will be seen in study on the muscles of the cadaver. One can easily cut between the muscles without dividing them and if this is done the operation will not be successful.

There is free bleeding and it is usually necessary to pack the wound and leave the packing in for 3 to 4 days. No suturing is necessary and an ice bag is applied after operation. The upper lip will be heavy and edematous and the discoloration caused by subcutaneous blood will require about 2 weeks to clear up.

The incisions just described sacrifice branches of the facial and infraorbital nerves. Interrup-



Fig. 1. Left: Face in repose, incisors and canines exposed.  
Fig. 2. Face smiling—not only teeth but alveolar ridge is exposed.

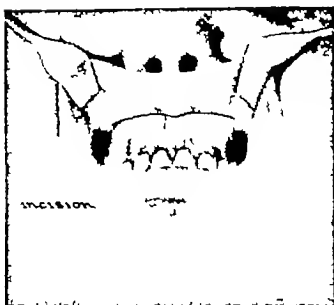


Fig 3

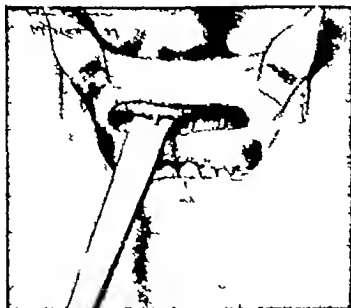


Fig 4



Fig 5

Fig 3 The line of incision in the labiodental fold

Fig 4 The method of elevating the tissues from the maxilla.

Fig 5 The following muscles are divided levator labii superioris, levator labii superioris alae que nasi and muscles below the nose

tion of the facial branches is desirable, inasmuch as it increases the permanence of the immobilization of the severed muscles

Section of the infraorbital branches causes some postoperative anesthesia. This is not permanent and normal sensation takes place within 2 to 3 months

I have been amazed at the havoc which this common deformity plays upon the morale of those afflicted and I have been equally amazed by the satisfaction obtained by the operation outlined

The pictures describe better the method of operation than any words we can use

# A TECHNIQUE FOR TRANSPLANTING THE ULNAR NERVE

Professor J. R. LEARMONTH, M.B., F.R.C.S. (Edin.) Edinburgh, Scotland

**T**RANSPLANTATION of the ulnar nerve may be required in three sets of circumstances: (1) to help to overcome gaps in the nerve before suture; (2) for the relief of ulnar neuritis following old fractures of the external condyle of the humerus, in which cubitus valgus is a sequel ("tardy ulnar palsy") and (3) for the relief of the ulnar neuritis which may appear in late middle life in those who have

mild degree of congenital hyperextension of the elbow with mild cubitus valgus. It is frequently employed for war wounds involving the ulnar nerve and tardy ulna palsy may appear in recruits who are required to reach a high standard of physical fitness.

Though the technique to be described is first used because of loss of muscle tissue at the origin of the flexor-pronator group of muscles, it has been

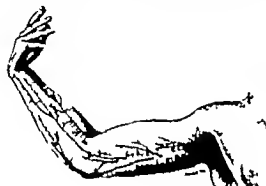


Fig. 1



Fig. 2

Fig. 2. Transparency showing (dotted lines) the most common arrangement of the cutaneous nerves in the area of operation and (continuous line) the incision, which is calculated to avoid the majority of them. An incision convex anteriorly, like leaving scar more free from subsequent pressure, almost inevitably divides cutaneous twigs, and this may be followed by most annoying paresthesia along the medial aspect of the forearm.



Fig. 3



Fig. 4

Fig. 3. The incision is made down to the deep fascia. Its lateral lip is raised to expose the flexor-pronator which the flap so formed may be seen the roots of branches of the medial cutaneous nerve of the forearm.

Fig. 3. The ulnar nerve is isolated proximal to the medial epicondyle, and gently raised on tape mounted with physiologic saline solution. The vessels which accompany the nerve are preserved as far as possible; any branches which must be divided are tied with o/s catgut.

Fig. 4. The aponeurotic roof of the ulnar groove is divided, either by a scalpel or a director or by narrow-bladed scissors introduced on the flat, as far from the nerve as possible.

used in subsequent cases in which transplantation of the nerve has been required, because it places the nerve in an intermuscular interval, where nerves normally run



Fig 5

Fig 5 The ulnar nerve is dissected between the two heads of the flexor carpi ulnaris. The branches of the nerve to the joint, and to the ulnar head of flexor carpi ulnaris, are identified and freed. The operator separates these nerve bundles from the trunk of the ulnar nerve by means of sharp dissection.

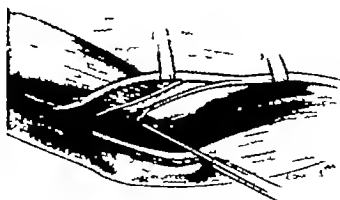


Fig 6

Fig 6 The branches of the nerve have been freed. It is often necessary to sacrifice a branch to the elbow joint (seen isolated by a hook).



Fig 7

Fig 7 The flexor pronator origin is divided from medial to lateral borders, beginning at the cleft between the two heads of flexor carpi ulnaris.

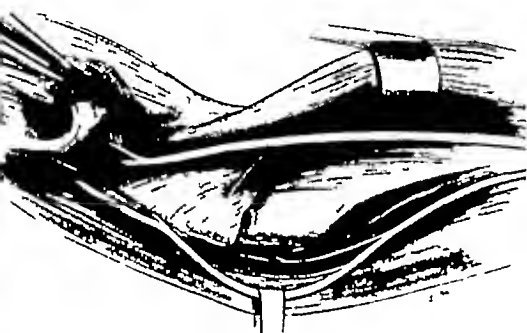


Fig 8 (Semidiagrammatic) The flexor pronator muscles are turned distally, thus exposing the median nerve, and the leash of branches from it innervating this group.

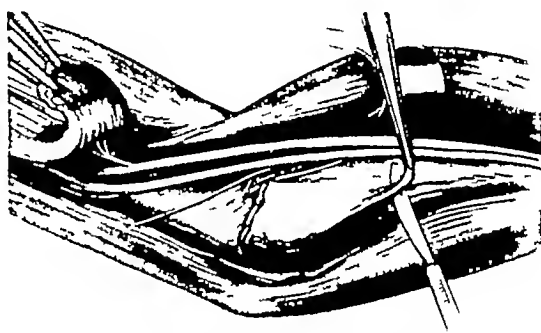


Fig 9 The ulnar nerve is laid beside the median nerve. The medial intermuscular septum is carefully and cleanly removed.

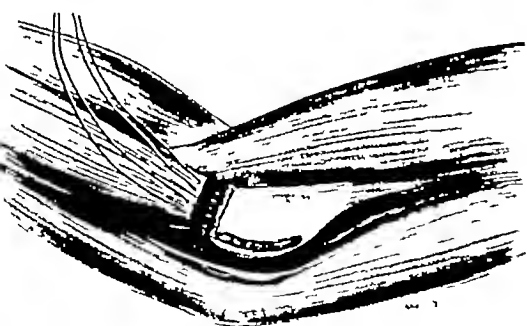


Fig 10 The flexor pronator muscles are reattached to their origin by means of mattress sutures of either silk or linen.

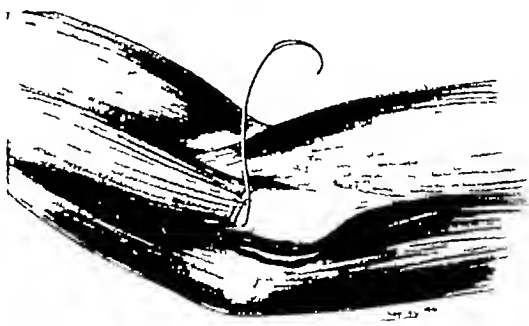


Fig 11 The gap between the two heads of flexor carpi ulnaris is closed by a continuous catgut suture, which also acts as a hemostatic suture.



16, 14, 13, and 13 pounds. It was deduced, therefore, that mechanical fixation alone had an initial tensile strength of 6 to 16 pounds and that normal physiological fixation of tendon to bone was greater than the tensile strength of the musculo-tendinous junction, which varied from 27 to 40 pounds. The curve of tensile strength, therefore, begins somewhere between 6 to 16 pounds and progresses to 27 pounds (Fig 2).

With few exceptions, the tensile strength of attachment of tendon to bone for comparable periods of time in the 18 dogs comprising group I were in close agreement with each other, though there were some inexplicable differences: dogs 46 and 54 (Table I). The discrepancies, however, were usually the result of a tendon rupturing rather than differences in strength of union. A small drill-hole, therefore, offers no advantage and presents the technical disadvantage of pulling a tendon through a hole in which it fits snugly.

The tensile strength curves for attachment of bone to tendon have the same general shape as those for other healing wounds. During the lag period the tensile strength falls and is less than that of freshly sutured tendon. It then rises gradually during the period of fibroplasia, being much sharper in group II. Normal physiological

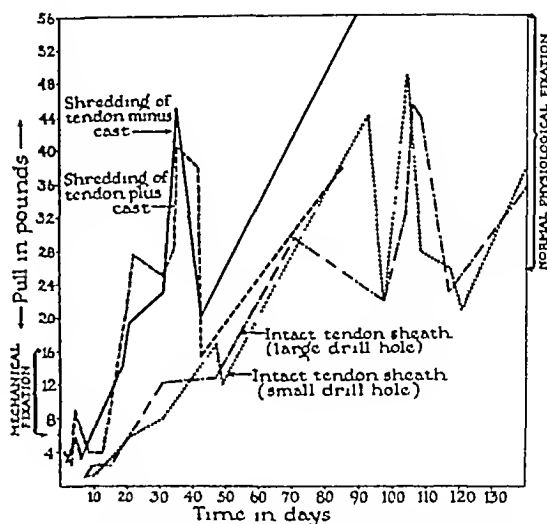


Fig 2 The curve of tensile strength begins somewhere between 6 and 16 pounds and progresses to 27 pounds

TABLE II — EFFECT ON TENSILE STRENGTH OF SHREDDING OF TENDON, INTERPOSING BONE SAND BETWEEN THE FIBERS AND IMMOBILIZATION

TABLE I — EFFECT OF RELATIVE SIZE OF TENDON TO DRILL-HOLE IN NONIMMOBILIZED DOGS

Dog	Days	Small hole—lbs pull	Large hole—lbs pull	Comments
40	9	1½	1½	Avulsed
45	10	1½	2	Avulsed
53	15	3	3	Avulsed
47	21	6	Slipped	Avulsed
27	31	8	12	Avulsed
2	47	16½	12½	Avulsed
8	49	12	15	Avulsed
44	71	Slipped	29½	Avulsed
46	93	44	Slipped	Tendon ruptured
54	96	22	22	Avulsed wound clean
51	104	49	32	Tendon ruptured
5	104	43	45	Tendon ruptured
49	109	28	44	Tendon ruptured
9	117	26	23	Musculotendinous junction separated
43	121	21	25	
7	136	Slipped	Slipped	
41	150	Slipped	Slipped	
48	173	38	36	Tendon ruptured

Dog	Days	Cast days	Right cast	Left no cast
61	1	1	4	Slipped
62	2		2½	Slipped
67	5	5	6	3
68	5	5	9	6
71	7	7	3	2½
63	7	7	2½	Slipped
72	10	10	5	7
64	14	14	4	Slipped
69	14	14	11	8
65	19	19	20	19
66	19	19	27	14
74	28	18	25	21
70	28	18	26	32
57	35	18	25	23
58	35	30	28	45
59	35	23	40	34½*
60	42	17	38	26†
56	42	21	15	20†
73	58	30	34	46
55	89	30	38	58

\*One tore rather than avulsed

†R. tore, L. avulsed

‡Avulsed cleanly

# A STUDY OF TENDON IMPLANTATIONS INTO BONE

GRAHAM A. KERNWEIN M.D. Chicago, Illinois

**S**TRICT adherence to certain fundamental principles is essential to successful tendon transplants. Experience has demonstrated that firm anchorage is best obtained when a tendon is implanted into a hole drilled through a bone. The trauma of the drill creates conditions locally in the bone which closely simulate those present in a fracture except that the supporting function is not reduced. Hemorrhage is present with organization of the clot by fibroblasts and the formation of osteoblast which in turn form a bony wall about the transplant. The resulting firm anchorage is due to the gradual ossification and incorporation of the tendon in the bone which occurs in two ways (1) by replacement by invading osteoblasts which form bone and (2) by metaplasia (3) Ossification of the transplant is most marked in the cortical area and is only minimal in the medullary region. Although firm anchorage usually follows these implantations, Galtie has reported failures in human beings and in experimental animals.

Opinions differ as to the time required for firm anchorage. Mayer states that when a tendon is anchored properly mechanical and physiological fixation overlap and early functioning of the tendon is a safe procedure. Studies of wound healing, however, do not lend credence to Mayer's state-

ment. Howe, Som and Harvey found a lag period of 4 to 6 days between the initial injury and beginning diminution in the surface area of the wound, followed by a period of fibroplasia and a coincident rapid rise in tensile strength from the 6th to 10th days. Mason and Allen in study of healing sutured tendons, found a lag period during which the tensile strength of the union showed an initial drop below that of sutured fresh tendons. Their best results were obtained with immobilization for 2 weeks followed by 4 weeks of restricted activity.

The foregoing experimental work concerned soft tissues. In the attachment of bone to tendon, the maturation of the fibrous tissues into bone introduces a hitherto unstudied factor. The following studies were made to establish the time factors of the lag fibroplasia and maturation periods of the attachment of tendon to bone.

The tendon of the extensor carpi radialis longus muscle was transplanted bilaterally into the radius satisfactorily in 35 of 52 dogs. In the first of 2 groups, the tendon sheath was left intact and a small drill-hole made so that the tendon fit snugly.

Larger drill-hole was made in the other leg (Table I). In the second group, the portion of the tendon implanted in the bony tunnel was stripped of its sheath its component fibers were separated, and bone sand from the drill-hole was interposed among the strands. One limb operated upon was immobilized in cast (Table II). The animals were sacrificed at intervals of 1 to 173 days and the tensile strength of the union between the bone and tendon measured. These measurements are compared with the tensile strength of the mechanical fixation only and of the normal extensor carpi radialis longus attachment to bone.

The tensile strength was measured on a machine designed by M. von. It was difficult to find a method whereby the tendon could be held securely yet not be cut by the apparatus and thus reduce its tensile strength. The musculotendinous junction 12 days separated with a pull of from 27 to 38 pounds. In no instance did the tendon separate from its insertion into the bone though on 4 occasions the pull exceeded 50 pounds. In 6 dogs the extensor carpi radialis longus tendon was transplanted through the radius and secured and the tensile strength tested immediately. The tensile strength of the mechanical fixation was 6, 9,



Fig. Bone sand, A interposed among the scarred strands of transplanted tendon, B The bony spicules are devoid of cells, resorption of the necrotic bone sand by the surrounding tissue is seen, C There is no new bone formation. X45.

16, 14, 13, and 13 pounds. It was deduced, therefore, that mechanical fixation alone had an initial tensile strength of 6 to 16 pounds and that normal physiological fixation of tendon to bone was greater than the tensile strength of the musculo-tendinous junction, which varied from 27 to 40 pounds. The curve of tensile strength, therefore, begins somewhere between 6 to 16 pounds and progresses to 27 pounds (Fig 2).

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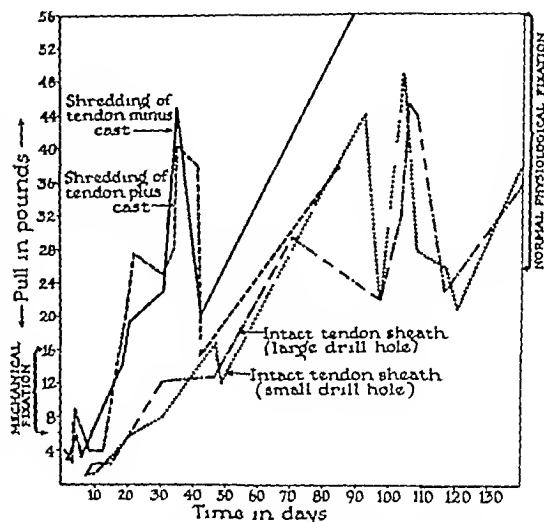


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73	58	30	34	46
55	80	30	38	58

\*One tore rather than avulsed  
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fixation is attained in 35 days as compared with 71 days in group I (Fig. 2).

Corresponding readings in immobilized and nonimmobilized limbs being equally high, immobilization was not responsible for the increased rate of attachment in group II. Bone transplanted into soft tissues (6) having no function to perform atrophied and diminished in size. The bone sand transplanted among the avascular tendon fibers underwent aseptic necrosis (Fig. 1) and gradually was resorbed. In no instance did it stimulate the surrounding tenoblasts or fibroblasts to form bone. Stripping of the tendon sheath and shredding the component fibers presented larger area for invasion by vascularized connective tissue. Theoretically a larger area for attachment and incorporation of tendon into bone should result in rapid rise in tensile strength. Slipping of the tendon relaxes the tension of the transplanted muscle and, despite firm anchorage, poor function results. Slipping is prevented by immobilization of the limb in a cast for a maximum of 21 days which carries the mechanical fixation over the lag period until physiological fixation takes place. Prolonged immobilization results in an atrophy of disuse and retards the rate of fixation (Table II dogs 55 and 58).

#### CONCLUSIONS

1. The firm anchorage from tendon drawn through a drill-hole in bone is due to the ossifica-

tion and gradual incorporation of the tendon in the bone.

2. During the lag period in the union of tendon to bone the tensile strength falls below that of the initial mechanical fixation.

3. Immobilization in a cast for 21 days carries the mechanical fixation over the lag period until physiological fixation occurs.

4. Prolonged cast immobilization retards the tensile strength of union.

5. The relative size of tendon to drill-hole has little effect upon the rate of union of tendon to bone.

6. Bone sand interposed between the strands of shredded tendon undergoes aseptic necrosis and is resorbed.

7. Shredding of the portion of the tendon implanted in bone permits the surrounding fibroblasts to permeate and by increasing the surface area of anchorage accelerates the rate of rise of tensile strength.

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# EDITORIALS

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DECEMBER, 1942

### AN APPRAISAL OF CYCLOPROPANE

CYCLOPROPANE has been in extensive clinical use for about ten years. The experience gained in this period is not great enough to permit final statements to be made concerning the value of the agent, however, the use of cyclopropane has been wide enough and the trial long enough to permit a considered appraisal of its present status. If this approach to the subject appears to be unduly cautious, it should be recalled that although plans are being made for the celebration of the one hundredth anniversary of the introduction of ether into wide clinical usage, its merits are still disputed by well informed men. The past ten years has provided us with many facts concerning cyclopropane. Certain characteristics of the agent have become well established. These can be set down and considered in their proper relationship to those of other agents, for an estimation of the range of usefulness of cyclopropane can be made only upon such a com-

parative basis. What, then, are the outstanding characteristics of this agent?

First, cyclopropane is potent. Anesthesia is produced by a low concentration in the central nervous system. Notwithstanding the considerable potency of the agent, it does not in all cases provide a degree of muscular relaxation comparable to that produced by ether at a safe level of anesthesia.

It is possible to administer a high percentage of oxygen with cyclopropane, as much as 80 per cent, and yet obtain a surgical level of anesthesia. This is a characteristic of great importance, particularly evident when it is compared with the 10 per cent oxygen available under nitrous oxide or the 20 per cent under ethylene. Curiously, many have overlooked the fact that with ether 96 per cent oxygen is permissible during full surgical anesthesia. An excess of oxygen in the inspired air is permissible with both cyclopropane and ether.

The fact that cyclopropane is only slightly soluble in the blood plus the fact that it can be administered in high partial pressure—in concentrations varying from 10 to 35 per cent or higher—in the inspired air, means that induction of anesthesia and recovery from it will be rapid. Then, since the agent is potent, deep anesthesia can be reached quickly. The great speed of action of cyclopropane makes possible swift overdosage in the hands of the inexperienced or careless. Is rapidity of effect of real clinical importance? Is the fact that induction and recovery with cyclopropane are faster than with ether of significance to the welfare of the patient? Under most circumstances, probably it is not. In the unusual case, however, it may be of great importance.

as for example in surgical shock. Available experimental information suggests that cyclopropane is a better anesthetic agent than ether for use in the rare case when general anesthesia must be induced in a patient in shock (this matter requires much more clinical testing than has yet been possible) yet cyclopropane appears to be a poorer choice than regional block or local infiltration, or ethylene anesthesia when these are adequate for the task at hand.

Cyclopropane or ethylene or nitrous oxide or infiltration or spinal anesthesia disturb the carbohydrate metabolism of the body very little, whereas ether considerably disturbs it. In the well controlled diabetic this effect is of little importance in operations of an hour and a half or so. In the infrequent case in which general anesthesia must be carried out in a patient with uncontrolled diabetes or in greatly prolonged operations the choice of ether is unwise the choice of the other agents better.

While cyclopropane is less irritant than is ether it is somewhat irritating to mucous membranes. Notwithstanding many expressions of opinion to the contrary no satisfactory demonstration has yet been recorded that the irritating quality of any of the commonly used anesthetic agents is of importance in mortality or even morbidity as far as the postoperative pulmonary complications are concerned.

In the past year or two a considerable change of attitude of surgeons toward cyclopropane has become apparent. The early enthusiastic approval of many has in some cases given way to questionings and doubt. These are based chiefly upon two characteristics the seriously toxic cardiac effects and a high degree of explosibility.

Much laboratory work and several clinical electrocardiographic studies have shown that

cyclopropane produces an ominous type of cardiac irregularity extrasystoles which arise from multiple foci in the ventricles. Experimentally these have at times been shown to come in runs which develop into ventricular fibrillation. Clinically a good many sudden deaths on the operating table have occurred with only brief warning. These have occurred under circumstances which suggest that ventricular fibrillation has been the cause. Such cardiac effects of cyclopropane are like those of chloroform. Indeed as with chloroform the chief cause of sudden death under cyclopropane appears to be abrupt heart failure. Available reports indicate that even in the hands of experts, the death rate attributable to cyclopropane is disturbingly high.

On theoretical grounds alone there are reasons why cyclopropane might better be avoided in patients with thyrotoxicosis. Clinical practice supports this stand. Disasterous experiences over the country have recently indicated that the use of cyclopropane in the presence of thyrotoxicosis is unwise. Deaths which have occurred in these cases have appeared to be due to ventricular fibrillation.

It has been learned on the basis of both experimental and clinical experience that the use of sympathomimetic drugs, as adrenalin are contraindicated when cyclopropane is to be used. Cyclopropane must not be used as a supplement to local anesthesia which has been administered with a vasoconstrictor agent, again because of the danger of fatal ventricular fibrillation.

Much has been written on the subject of the explosibility of anesthetic agents. It has been stated that ether and cyclopropane are equally explosible. If this statement means that the result of explosion of the two agents is the same it does not agree with the facts at hand. To be sure fatal explosion can result from the careless use of flame around either

## EDITORIALS

agent. Such carelessness can usually be eliminated in well run operating rooms. A fact that is sometimes not made clear in this regard is that the hazard from electrostatic sparks, a hazard which has not yet been brought adequately under control, is by no means the same with ether and with cyclopropane. Available data indicate that the hazard of a fatal explosion due to static spark is considerably greater with cyclopropane than it is with ether. The reasons for this are not yet clear. They may be associated with a greater detonating force of cyclopropane, or with the greater tendency of the cyclopropane explosion to propagate itself. A cyclopropane explosion will easily cross barriers that would extinguish an ether explosion.

We have, then, in cyclopropane, an agent which permits the use of a high percentage of oxygen, effects a rapid induction of anesthesia and a rapid recovery, is only slightly irritating to mucous membranes, produces little disturbance of the carbohydrate metabolism. The high oxygen permissible is important although cyclopropane is exceeded by ether in this regard. The other characteristics men-

tioned are of infrequent importance. Pitted against these qualities we find serious cardiac effects apparently responsible for a relatively high mortality, and finally a serious explosion hazard exists. In numbers, deaths from explosions are not great. The threat of explosion constantly on the mind of the operating team, a threat unquestionably greater with the use of cyclopropane than of ether, and the serious effects of an explosion to everyone concerned once it does take place, are not to be discounted.

As far as can be determined now, this agent is of great value on some occasions. Its bad qualities appear to be of such magnitude that it cannot safely be accepted as a substitute for ether or ethylene for most inhalation anesthesia, nor can it to any great extent supplant nitrous oxide in that agent's narrow range of usefulness. Unquestionably cyclopropane deserves further study and very probably it will come to have a permanent place among the resources of the well trained anesthetist. It appears likely that its range of usefulness will be much narrower than was at first predicted.

HENRY K. BEECHER

## BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgments must be regarded as sufficient return for the courtesy of the reader. Selections will be made for review in the interests of our readers and as space permits.

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